



**SNAKE RIVER SOCKEYE SALMON  
CAPTIVE BROODSTOCK PROGRAM  
RESEARCH ELEMENT**

**ANNUAL PROGRESS REPORT  
January 1, 2010—December 31, 2010**



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# **SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM RESEARCH ELEMENT**

## **2010 Annual Project Progress Report**

**Part 1—Project Overview**

**Part 2—*Oncorhynchus nerka* Population Monitoring and Redfish  
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**Part 3—Sockeye Salmon Juvenile Out-migrant and Adult Spawning  
Monitoring and Evaluation**

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## PART 1—PROJECT OVERVIEW

### BACKGROUND

The Idaho Department of Fish and Game (IDFG) initiated the Snake River Sockeye Salmon *Oncorhynchus nerka* Captive Broodstock Program in May 1991 in response to the decline of anadromous returns to the Sawtooth Valley in central Idaho. Waples et al. (1991) described Snake River sockeye salmon as a species on the threshold of extinction, and it was listed as endangered under the Endangered Species Act (ESA) on November 20, 1991 (ESA; 16 U.S.C.A. §§1531 to 1544). Snake River sockeye salmon are one of 28 stocks of Pacific salmon and steelhead (*Genus: Oncorhynchus*) in the Columbia River basin currently listed as threatened or endangered under the Endangered Species Act (<http://www.nwr.noaa.gov/ESA-Salmon-Listings/upload/snapshot-7-09.pdf>) (NOAA 2005).

Historically, Redfish, Alturas, Pettit, Stanley, and Yellowbelly lakes supported sockeye salmon in the Sawtooth Valley (Chapman et al. 1990; Evermann 1895; Bjornn et al. 1968) (Figure 1). Historical observations and discussions with local residents by Evermann (1895; 1896) described the Sawtooth Valley lakes as being important spawning and rearing areas for sockeye salmon; actual adult escapement enumeration or estimations were not conducted. Adult sockeye salmon escapement to Redfish Lake was enumerated from 1954 through 1966 by the IDFG, University of Idaho, and the United States Bureau of Commercial Fisheries. During this time, adult escapement ranged from a high of 4,361 in 1955 to a low of 11 in 1961 (Bjornn et al. 1968). Adult escapement enumeration was reinitiated in 1985 by the IDFG. Between 1985 and 1990, 62 adults were estimated to have returned to the Sawtooth Valley. No redds or anadromous adults were identified in Redfish Lake in 1990. Hydropower development, water withdrawal and diversions, water storage, harvest, predation, and inadequate regulatory mechanisms were outlined as factors contributing to the Snake River sockeye salmon's decline (Federal Register 1991).

The National Marine Fisheries Service (NMFS) listed Snake River sockeye salmon as an endangered species under the 1973 Endangered Species Act (as amended in 1978) in November of 1991 (Federal Register 1991). A population is considered a distinct population segment and, hence, a species for purposes of the Endangered Species Act if it represents an evolutionary significant unit of the biological species (Waples 1991). To be considered an evolutionary significant unit, a stock must satisfy two criteria: 1) it must be reproductively isolated from other conspecific population units; and 2) it must represent an important component in the evolutionary legacy of the biological species (Waples 1991). At the time of listing, the Redfish Lake sockeye salmon population was the only remaining sockeye salmon population of the Snake River sockeye salmon stock. Snake River sockeye salmon are one of three remaining stocks of sockeye salmon in the Columbia River system; the other two stocks, Okanogan Lake sockeye salmon and Wenatchee Lake sockeye salmon, are located in tributaries of the upper Columbia River. Approximately 1,127 river kilometers separate Snake River sockeye salmon from the nearest sockeye salmon populations in the upper Columbia River. Additionally, there has been no reported evidence of straying of sockeye salmon from the upper Columbia River into Redfish Lake (Waples et al. 1991; Winans et al. 1996). Mitochondrial DNA analyses completed in 2003 confirmed the genetic isolation of the upper Columbia River stocks from the Snake River sockeye salmon stock (Faler and Powell 2003).

Sockeye salmon returning to Redfish Lake travel a greater distance from the Pacific Ocean (1,448 river kilometers) and to a higher elevation (2,138 meters) than any other sockeye salmon population in the world. Additionally, Redfish Lake supports the species' southernmost

population within its recognized range (Burgner 1991). Together these characteristics presented a strong argument for the ecological uniqueness of the Snake River habitat and for the unique adaptive genetic characteristics of the Snake River sockeye salmon stock (Waples et al. 1991).

Genetic investigations conducted during and after Snake River sockeye salmon were listed further refined genetic relationships between anadromous sockeye salmon, residual sockeye salmon, and resident kokanee present in Redfish Lake. The presence of all three of these life history strategies of *O. nerka* in Redfish Lake complicated the ESA listing. Anadromous *O. nerka* (sockeye salmon) spawn on the shoals of the lake in October and November. Juveniles out-migrate during the spring from their nursery lake at age-1 or age-2 and remain in the ocean for one to three years before returning to their natal area to spawn. Residual *O. nerka* (sockeye salmon) spawn with anadromous sockeye salmon on the shoals of the lake in October and November. Residual sockeye salmon spend their entire life in their nursery lake. Variable proportions of anadromous and residual progeny may conform to a residual life history pattern. Resident *O. nerka* (kokanee) also complete their lifecycle in freshwater. They remain in Redfish Lake until maturation and spawn in Fishhook Creek, a tributary creek to Redfish Lake, in August and September. Kokanee are nonindigenous to Redfish Lake and were periodically stocked from a range of hatchery sources beginning in 1930 and continuing through 1972 (Bowler 1990). Redfish Lake anadromous sockeye salmon, residual sockeye salmon, and out-migrants were determined to be genetically similar, whereas kokanee were found to be genetically different (Brannon et al. 1992, 1994; Cummings et al. 1997; Waples et al. 1997). Because of their genetic similarity, residual sockeye salmon were added to the ESU listing in 1992.

## **SNAKE RIVER SOCKEYE SALMON CAPTIVE BROODSTOCK PROGRAM**

The Snake River Sockeye Salmon Captive Broodstock Program collected fish from the following sources for broodstock and reintroduction purposes: 1) anadromous adult returns that were trapped between 1990 and 1998 and retained for hatchery spawning, 2) residual adults that were trapped between 1992 and 1995 and retained for hatchery spawning, and 3) smolts that were trapped between 1991 and 1993, reared until maturity, and spawned in the hatchery. Seventh generation lineages of the founders are currently in captive broodstock culture. Both IDFG and National Oceanic and Atmospheric Administration (NOAA) Fisheries maintain Snake River sockeye salmon captive broodstocks. Groups of fish are reared at two facilities to avoid the potential catastrophic loss of the unique genetics of the stock. Idaho Department of Fish and Game rears annual captive broodstocks from the egg stage to maturity at Eagle Fish Hatchery in Eagle, Idaho (Johnson 1993; Johnson and Pravecek 1995, 1996; Pravecek and Johnson 1997; Pravecek and Kline 1998; Kline and Heindel 1999; Kline et al. 2003a, 2003b; Kline and Willard 2001; Willard et al. 2003a; Baker et al. 2005a, 2005b, 2006, 2007, 2008). Additionally, NOAA Fisheries rears annual captive broodstocks from the egg stage to maturity at the Manchester Research Station and Burley Creek Hatchery near Seattle, Washington (Flagg 1993; Flagg and McAuley 1994; Flagg et al. 1996, 2001; Frost et al. 2002, 2008).

The IDFG and NOAA Fisheries captive broodstock programs have produced approximately 5,016,129 eyed eggs from 1991 through 2010 (Table 1). Each year approximately 1,200 eggs are selected to be reared in the hatchery as an annual captive broodstock; the remaining eggs are utilized for reintroduction into the habitat.

The development of captive broodstock program reintroduction plans follows a “spread-the-risk” philosophy incorporating multiple release strategies and multiple lakes (Hebdon et al.

2004). Progeny from the captive broodstock program are reintroduced to Sawtooth Valley waters at different life stages using a variety of release options including: 1) eyed egg plants to in-lake incubator boxes in November and December, 2) presmolt releases direct to lakes in October, 3) smolt releases to outlet streams in May, and 4) prespawn adult releases (hatchery-reared) direct to lakes in September. All hatchery-reared presmolt and smolt release groups are uniquely marked to identify release strategy and release origin. To date, approximately 3,542,922 sockeye salmon eggs and fish have been reintroduced to Sawtooth Valley waters (Table 2). Overall survival to release (over different strategies) from the eyed egg stage of development has averaged just over 70% for the program.

Life history traits exhibited by wild sockeye salmon and habitat carrying capacity evaluations conducted by the Shoshone-Bannock Tribes (SBT) (Teuscher and Taki 1995, 1996; Taki and Mikkelsen 1997; Taki et al. 1999; Griswold et al. 2000; Lewis et al. 2000; Kohler et al. 2001, 2002, 2008) influence annual release plans. Bjornn et al. (1968) conducted smolt out-migration and adult return monitoring between 1954 and 1966; their work provides a detailed account of sockeye salmon life history in Redfish Lake. Smolt out-migration from Redfish Lake begins in early April, peaks in mid-May, and is complete by mid-June. Smolts out-migrate at either age-1 or age-2; the proportion of age-1 and age-2 smolts varies every year. During their 11-year study, Bjornn et al. (1968) noted a dominance of age-1 smolts for six of the 11 years. Age-2 smolts ranged from 2% to 77% of the total out-migration over the course of the early monitoring effort. Age-2 smolts are common in many other sockeye salmon lakes. The reasons for the additional freshwater residence time are unclear (Burgner 1991). Smolt fork length ranges between 45 mm and 140 mm. Adult sockeye salmon begin arriving at Redfish Lake Creek in mid-July and continue escapement through mid-October. Sockeye salmon spawn over submerged beach substrate of the lake; spawning peaks in mid-October. Returning adults are primarily two-ocean fish (Bjornn et al. 1968).

Efforts to prevent extinction of the Snake River sockeye salmon are coordinated through the Stanley Basin Sockeye Technical Oversight Committee (SBSTOC), a team of biologists representing IDFG, the SBT, NOAA Fisheries, and the University of Idaho. The Bonneville Power Administration provides coordination for the SBSTOC process.

## **PROJECT GOALS**

The immediate goal of the program is to utilize captive broodstock technology to conserve the population's unique genetics. Long-term goals include increasing the number of individuals in the population to address NOAA's interim abundance guidelines and to provide sport and treaty harvest opportunity. Draft ESA delisting criteria for Snake River sockeye salmon includes the return of 1,000 adults to Redfish Lake, 500 adults to Pettit Lake, and 500 adults to Alturas Lake for two generations (NMFS 2002). Interim abundance targets must be met without relying on hatchery production (e.g., natural origin adults).

## **PROJECT OBJECTIVES**

1. Develop captive broodstocks from Redfish Lake sockeye salmon, culture broodstocks, and produce progeny for reintroduction.
2. Determine the contribution hatchery-produced sockeye salmon make toward avoiding population extinction and increasing population abundance.

3. Describe *O. nerka* population characteristics for Sawtooth Valley lakes in relation to carrying capacity and broodstock program reintroduction efforts.
4. Utilize genetic analysis to discern the origin of wild and broodstock sockeye salmon to provide maximum effectiveness in their utilization within the broodstock program.
5. Transfer technology through participation in the technical oversight committee process, provide written activity reports, and participate in essential program management and planning activities.

Idaho Department of Fish and Game's participation in the Snake River Sockeye Salmon Captive Broodstock Program includes two areas of effort: 1) sockeye salmon captive broodstock culture, and 2) sockeye salmon research and evaluations. Although objectives and tasks from both components overlap and contribute to achieving the same goals, work directly related to sockeye salmon captive broodstock culture appears under a separate cover (Baker et al. 2011). Research and evaluation activities associated with Snake River sockeye salmon are permitted under NOAA permit Nos. 1120, 1124, and 1481 (for a review see Kline 1994; Kline and Younk 1995; Kline and Lamansky 1997; Hebdon et al. 2000; Hebdon et al. 2002; Hebdon et al. 2003; Willard et al. 2003b; Willard et al. 2005). This report details fisheries research information collected between January 1 and December 31, 2010. Research information includes *O. nerka* population monitoring in Sawtooth Valley lakes, sport fishery evaluation on Redfish Lake, smolt out-migration monitoring and evaluation at lake outlets, telemetry studies of mature adult sockeye salmon released to Sawtooth Valley lakes for natural spawning, and predator investigations in tributaries to Redfish and Alturas lakes.

## STUDY AREA

The program's recovery efforts focus on Redfish, Pettit, and Alturas lakes in the Sawtooth Valley located within the Sawtooth National Recreation Area (Figure 1). These lakes provide critical spawning and rearing habitat under the ESA listing. Lakes in the Sawtooth Valley are glacial-carved and considered oligotrophic. The three lakes range in elevation from 1,996 m (Redfish Lake) to 2,138 m (Alturas Lake) and are located 1,448 km (Redfish Lake) to 1,469 km (Alturas Lake) from the Pacific Ocean. Redfish Lake is the largest of the three lakes (615 ha), Pettit Lake is the smallest (160 ha), and Alturas Lake (338 ha) is intermediate in surface area (Table 3). Reintroduction efforts have been ongoing in Redfish Lake since 1993, Pettit Lake since 1995, and Alturas Lake since 1997.

In addition to *O. nerka*, numerous native and nonnative fish reside in the study lakes and streams within the Sawtooth Valley. Native fish present in Sawtooth Valley waters include: Chinook salmon *O. tshawytscha*, rainbow trout/steelhead *O. mykiss*, westslope cutthroat trout *O. clarkii lewisi*, bull trout *Salvelinus confluentus*, sucker *Catostomus* spp., northern pikeminnow *Ptychocheilus oregonensis*, mountain whitefish *Prosopium williamsoni*, redbside shiner *Richardsonius balteatus*, dace *Rhinichthys* spp., and sculpin *Cottus* spp. Nonnative species present in Sawtooth Valley waters include lake trout *S. namaycush* (Stanley Lake only), and brook trout *S. fontinalis*. Rainbow trout are released into Pettit, Alturas, and Stanley lakes in the summer to increase sportfishing opportunities. Sportfishing on Pettit, Alturas, and Stanley lakes is covered by Idaho's statewide general fishing regulations, which allow harvest of six trout per day (excluding bull trout, which must be released if caught) and 15 kokanee per day with no seasonal closures. Sportfishing regulations on Redfish Lake restrict kokanee fishing/harvest to

January 1 through August 7 to protect residual sockeye salmon. No trout have been stocked in Redfish Lake since 1992.

### **2009 and 2010 Captive Broodstock Program Egg and Juvenile Supplementation**

All hatchery origin sockeye salmon released to Sawtooth Valley waters were adipose fin-clipped to distinguish hatchery rearing origin and/or release strategy. A subsample of some of the release groups was PIT tagged prior to release.

In 2009, 233,942 sockeye salmon and 75,079 sockeye salmon eyed eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 4). Smolts were released to the Salmon River on May 7, 2009. A total of 173,055 BY07 smolts were released at two separate release sites (99,374 below the river water intake to SFH, and 73,681 into Redfish Lake Creek below the IDFG weir site). Smolts were reared at two locations: IDFG Sawtooth Fish Hatchery (SFH), and Oregon Department of Fish and Wildlife (ODFW) Oxbow Fish Hatchery (OFH). All sockeye smolts released were coded-wire-tagged, differentially marked (OFH fish were AD/RV clipped, SFH fish were AD-clipped) and had representative groups PIT tagged (10,937 OFH, 52,551 SFH). All presmolts released in 2009 were age-0 fish from brood year 2008 (BY08) reared at SFH. Redfish Lake received 34,561 presmolts (1,016 PIT tagged), Alturas Lake received 9,994 presmolts (1,019 PIT tagged), and Pettit Lake received 14,983 presmolts (1,018 PIT tagged) in October by direct lake releases. Six hundred eighty-two hatchery-produced adult sockeye salmon were released to Redfish Lake for volitional spawning in September. A total of 667 anadromous return adult sockeye salmon were released into Redfish Lake between September 8 and October 21, 2009 for volitional spawning. In November and December, 75,079 eyed eggs reared at NOAA Burley Creek Hatchery and Eagle Fish Hatchery were planted in Pettit and Alturas lakes (59,511 in Pettit Lake, 15,568 in Alturas Lake).

In 2010, 246,711 sockeye salmon and 59,683 sockeye salmon eyed eggs were released into Sawtooth Valley waters from the captive broodstock program (Table 5). Smolts were released to the Salmon River on May 4, 2010. A total of 179,278 BY08 smolts were released at two separate release sites (118,780 below the river water intake to Sawtooth Fish Hatchery (SFH) and 60,498 into Redfish Lake Creek below the IDFG weir site). Smolts were reared at two locations: IDFG SFH and ODFW Oxbow Fish Hatchery (OFH). All sockeye smolts released were coded-wire-tagged and had representative groups PIT tagged (11,945 OFH, 51,661 SFH). All presmolts released in 2010 were age-0 fish from brood year 2009 (BY09) reared at SFH and EFH (49,488 reared at SFH, 16,363 reared at EFH). Redfish Lake received 31,413 presmolts, Alturas Lake received 16,363 presmolts (1,319 PIT tagged), and Pettit Lake received 18,075 presmolts in July and October by direct lake releases. A total of 372 hatchery-produced adult sockeye salmon were released to Redfish Lake for volitional spawning in September. In addition, 1,210 anadromous return adult sockeye salmon were released into Redfish Lake between September 8 and October 7, 2010 for volitional spawning. In November and December, 59,683 eyed eggs reared at BCH and EFH were planted in Alturas Lake.

Table 1. Eyed egg production by IDFG and NOAA facilities for the Snake River sockeye salmon captive broodstock program 1991-2010.

Brood Year	Eyed Eggs Produced By IDFG	Eyed Eggs Produced By NOAA
1991	1,978	0
1992	36	0
1993	13,647	0
1994	259,536	48,000
1995	3,006	0
1996	110,756	381,500
1997	152,760	171,965
1998	15,580	47,533
1999	63,168	65,400
2000	253,047	94,500
2001	121,320	90,859
2002	66,324	60,516
2003	303,983	139,359
2004	140,823	135,699
2005	145,207	143,362
2006	258,342	190,603
2007	175,810	192,354
2008	220,334	134,105
2009	290,968	129,849
2010	228,822	165,078
<b>Total:</b>	<b>2,825,447</b>	<b>2,190,682</b>

Table 2. Snake River sockeye salmon captive broodstock program egg and fish reintroduction history 1993-2010.

Year of Reintroduction	Eyed Eggs	Presmolts	Smolts	Hatchery-Reared Adults	Anadromous Adults
1993	0	0	0	20	0
1994	0	14,119	0	65	0
1995	0	91,572	3,794	0	0
1996	105,000	1,932	11,545	120	0
1997	105,767	255,711	0	120	0
1998	0	141,871	81,615	0	0
1999	20,311	40,271	9,718	18	3
2000	65,200	72,114	148	71	200
2001	0	106,166	13,915	65	14
2002	30,924	140,410	38,672	178	12
2003	199,666	76,788	0	315	0
2004	49,134	130,716	96	241	0
2005	51,239	72,108	78,330	173	0
2006	184,596	107,292	86,052	464	0
2007	51,008	82,105	101,676	494	0
2008	67,984	84,005	150,395	398	571
2009	75,079	59,538	173,055	682	667
2010	59,683	65,851	179,278	372	1,210
<b>Total</b>	<b>1,065,591</b>	<b>1,542,569</b>	<b>928,289</b>	<b>3,796</b>	<b>2,677</b>

Table 3. Physical and morphometric characteristics of three study lakes located in the Sawtooth Valley, Idaho.

Surface Area (ha)	Elevation (m)	Volume (m <sup>3</sup> x 10 <sup>6</sup> )	Mean Depth (m)	Maximum Depth (m)	Drainage Area (km <sup>2</sup> )
615	1,996	269.9	<u>Redfish Lake</u> 44	91	108.1
338	2,138	108.2	<u>Alturas Lake</u> 32	53	75.7
160	2,132	45.0	<u>Pettit Lake</u> 28	52	27.4

Table 4. Sockeye salmon releases to Sawtooth Valley waters in 2009.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks <sup>a</sup>	Number PIT-tagged	Mean Release Weight (g)	Rearing Location
Redfish Lake Creek (below weir)	Smolt (2007)	05/07/2009	73,681	AD/RV/CWT	10,937	44.5	OFH
Salmon River (above SFH weir)	Smolt (2007)	05/07/2009	99,374	AD/CWT	52,551	14.8	SFH
Alturas Lake (direct lake)	Presmolt (2008)	10/07/2009	9,994	AD	1,019	6.8	SFH
Pettit Lake (direct lake)	Presmolt (2008)	10/07/2009	14,983	AD	1,018	6.2	SFH
Redfish Lake (direct lake)	Presmolt (2008)	10/07/2009	34,561	AD	1,016	6.0	SFH
Redfish Lake (direct lake)	Adult Captive	09/09/2009	60	AD	60	1,463	NOAA-BC
		09/11/2009	322	AD	322	1,208	EFH
		09/16/2009	69	AD	69	1,208	EFH
		9/16/2009	231	AD	231	2,114	NOAA-BC
	Adult Anadromous	9/8/2009	311	Mix	NA	1,259	EFH
		9/9/2009	244	Mix	NA	1,516	EFH
		9/9-10/21/2009	112	Mix	NA	1,372	Direct Release
Pettit Lake (direct lake)	Eyed egg (2009)	11/9/2009	2,601	NA	NA	NA	IDFG-EFH
		12/03/2009	47,867	NA	NA	NA	IDFG-EFH
		12/03/2009	9,043	NA	NA	NA	NOAA-BC
Alturas Lake (direct lake)	Eyed egg (2009)	12/17/2009	6,038	NA	NA	NA	IDFG-EFH
		12/17/2009	9,530	NA	NA	NA	NOAA-BC

<sup>a</sup> AD = adipose fin-clip, CWT = coded-wire-tagged, AD/RV/CWT = adipose fin, right ventral fin-clip, coded-wire-tagged, AD/LV/CWT = adipose fin, left ventral fin-clip, coded-wire-tagged.

<sup>b</sup> SFH = Idaho Department of Fish and Game Sawtooth Fish Hatchery; OFH = Oregon Department of Fish and Wildlife Oxbow Fish Hatchery; EAG = Idaho Department of Fish and Game Eagle Fish Hatchery; NOAA-BC = National Oceanic and Atmospheric Administration Burley Creek Hatchery.

Table 5. Sockeye salmon releases to Sawtooth Valley waters in 2010.

Release Location	Strategy (Brood Year)	Release Date	Number Released	Marks <sup>a</sup>	Number PIT tagged	Mean Release Weight (g)	Rearing Location
Redfish Lake Creek (below weir)	Smolt (2008)	05/04/2010	60,498	CWT	31,813	42.4	SFH/OFH
Salmon River (above SFH weir)	Smolt (2008)	05/04/2010	118,780	CWT	31,793	16.2	SFH/OFH
Alturas Lake (direct lake)	Presmolt (2009)	07/27/2010	16,363	AD	1,319	11.4	EFH
Pettit Lake (direct lake)	Presmolt (2009)	10/07/2010	18,075	AD	0	2.9	SFH
Redfish Lake (direct lake)	Presmolt (2009)	10/07/2010	31,413	AD	0	2.9	SFH
Redfish Lake (direct lake)	Adult Captives	09/08/2010	11	AD	11	2,702.4	NOAA-BC
		09/15/2010	2	AD	2	926.5	EFH
		09/15/2010	187	AD	187	1,008.9	NOAA-BC
		09/17/2010	172	AD	172	1,227.0	EFH
	Adult Anadromous	09/10/2010	331	Mix	2	1,565.3	EFH
		09/14/2010	297	Mix	5	1,542.1	EFH
		08/12-09/09/2010	582	Mix	16	NA	Direct Release
Alturas Lake (direct lake)	Eyed egg (2010)	12/01/2010	2,455	NA	NA	NA	NOAA-BC
		12/01/2010	15,296	NA	NA	NA	IDFG-EFH
		12/08/2010	31,708	NA	NA	NA	IDFG-EFH
		12/16/2010	461	NA	NA	NA	NOAA-BC
		12/16/2010	9,763	NA	NA	NA	IDFG-EFH

<sup>a</sup> AD = adipose fin-clip, CWT = coded-wire-tagged, AD/RV/CWT = adipose fin, right ventral fin-clip, coded-wire-tagged, AD/LV/CWT = adipose fin, left ventral fin-clip, coded-wire-tagged.

<sup>b</sup> SFH = Idaho Department of Fish and Game Sawtooth Fish Hatchery; OFH = Oregon Department of Fish and Wildlife Oxbow Fish Hatchery; EAG = Idaho Department of Fish and Game Eagle Fish Hatchery; NOAA-BC = National Oceanic and Atmospheric Administration Burley Creek Hatchery.

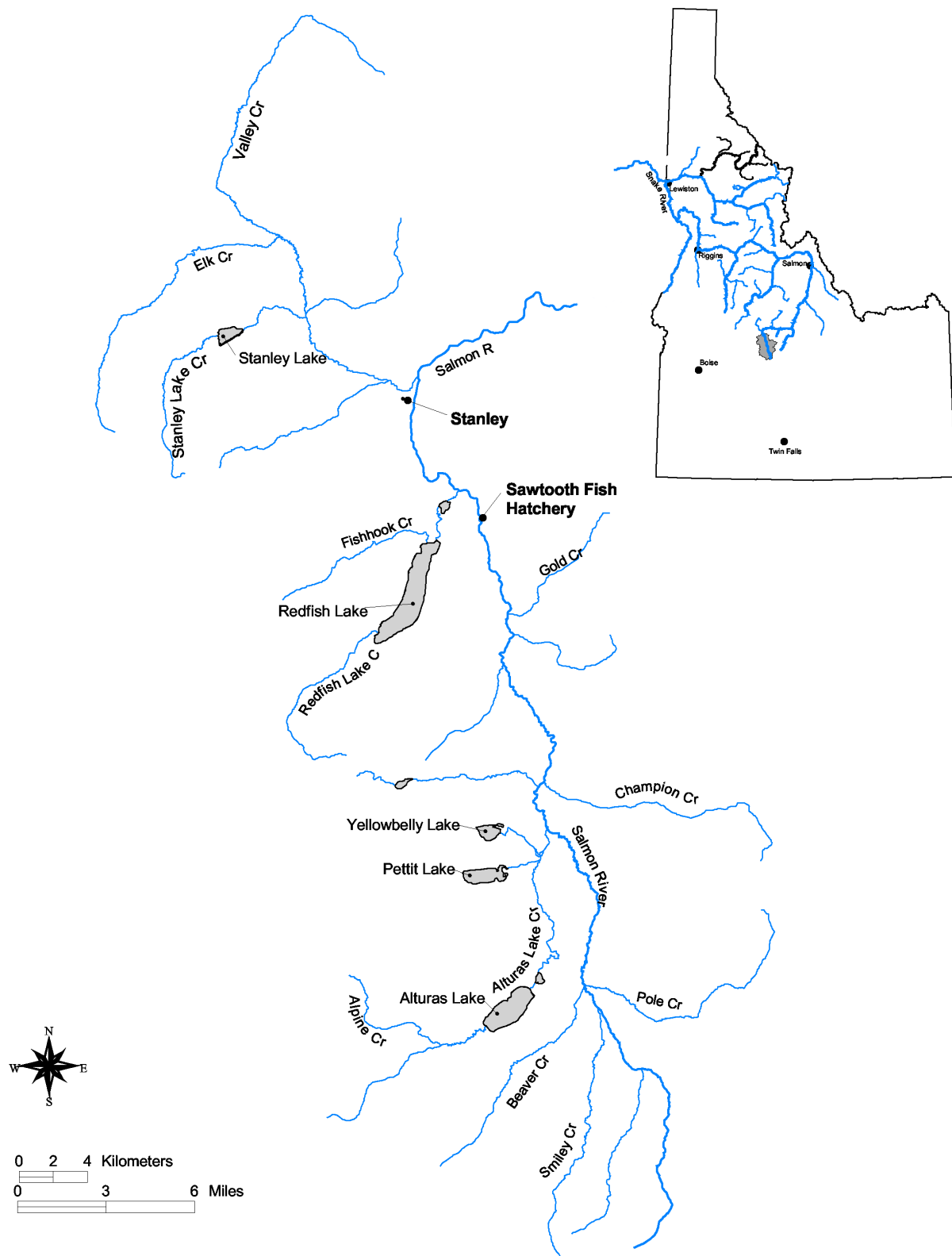


Figure 1. Map of the upper Salmon River watershed located in the Sawtooth Valley, Idaho.

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## **PART 2—ONCORHYNCHUS NERKA POPULATION MONITORING AND REDFISH LAKE SPORT FISHERY INVESTIGATIONS**

### **INTRODUCTION**

Understanding the dynamics of *O. nerka* populations in the Sawtooth Valley lakes is a vital part of sockeye salmon restoration efforts. Knowledge of *O. nerka* abundance coupled with limnology data (collected and reported by the Shoshone-Bannock Tribes [SBT]) is necessary for making responsible decisions regarding the reintroduction of sockeye salmon juveniles from the captive broodstock program. Utilizing multiple release strategies at various life stages allows program managers to design reintroduction plans that take advantage of the nursery lakes' current carrying capacities, which are estimated by trawling, hydroacoustic surveys, and limnological surveys (hydroacoustic and limnological surveys conducted and reported by the SBT). Productivity in the lakes varies annually and the presence of kokanee in the nursery lakes creates increased competition for limited food sources between kokanee and sockeye salmon. During years in which a lake is experiencing low productivity and/or high kokanee abundance, the program limits reintroduction efforts of individuals that would spend more time in nursery lakes and diverts individuals to more productive lakes.

The kokanee fishery on Redfish Lake was closed in 1993 due to the presence of ESA listed residual sockeye salmon but was reopened in 1995 (NOAA Permit 1481). The kokanee fishery was reopened based on the recommendation of the SBSTOC to reduce kokanee competition with sockeye salmon by removing spawning age kokanee through angler harvest. Permit 1481 (NOAA) requires IDFG to monitor angler harvest of listed sockeye salmon in Redfish Lake during the kokanee fishing season. The kokanee season on Redfish Lake opens on January 1 and closes on August 7, when mature kokanee initiate spawning in Fishhook Creek, while residual sockeye salmon remain in the lake.

The roving creel survey conducted on Redfish Lake during 2010 was designed to estimate total kokanee harvest and to collect tissue samples for genetic analysis from angler-harvested kokanee. The genetic analysis is used to estimate the number of unmarked sockeye salmon harvested incidental to the kokanee fishery within the lake.

### **METHODS**

#### **Oncorhynchus nerka Population Monitoring**

To estimate *O. nerka* (kokanee and sockeye salmon) abundance, density, and biomass in Sawtooth Valley lakes, midwater trawling was conducted at night during the dark (new) phase of the moon in October. Spawning-age kokanee (>250 mm fork length) in Redfish and Alturas lakes migrate to tributaries to spawn in August; therefore, trawling is conducted in October to prevent the collection of biased trawl catch data, and because juvenile *O. nerka* that remain in valley lakes are tightly stratified during this time of the year. Redfish, Pettit, and Alturas lakes were sampled October 4–6, 2010. Trawling was performed in a stepped-oblique fashion as described by Rieman (1992) and Kline (1994). A minimum of six trawl transects were conducted per lake. Total *O. nerka* abundance, density, and biomass were estimated using a program developed by Rieman (1992). Abundance estimates generated by this program are extrapolations of actual trawl catch data to the total area of the lake mid-depth in the observed *O. nerka* stratum. Density and biomass estimates are expressed in relation to lake surface area. Whenever possible, we estimated abundance, density, and biomass by individual age class

(assuming representation in the trawl). We calculated confidence intervals using the following formula of Scheaffer et al. (1990):

$$\bar{x} \pm t_{\alpha} \sqrt{\frac{s^2}{n}}$$

Fork length (1 mm) and weight (0.1 g) were recorded for all trawl-captured *O. nerka*; scales were removed from a subsample (a minimum of five fish from every 10 mm length group) and returned to the laboratory. Two program technicians aged scales to determine length ranges for age classification. Scales were mounted between microscope slides before aging and viewed with a microfiche. Stomachs were removed and preserved for diet analysis by SBT biologists. Fin clips were stored in 100% ethanol and delivered to the IDFG Genetics Laboratory for DNA analysis (Redfish Lake = 25, Pettit Lake = 26, and Alturas Lake = 21).

### **Redfish Lake Sport Fishery Investigations**

A roving creel survey was conducted from May 29 through August 6, 2010 (kokanee harvest closes on August 7 to protect residual sockeye salmon) on Redfish Lake. The creel census was stratified by 14-day intervals, broken into weekday and weekend day types and morning (0800 to 1400) and evening (1401 to 2000) instantaneous count periods. Angler counts were conducted four weekdays, two weekend days, and any holiday during each 14-day interval. On each angler count day, the number of boats and bank anglers were counted from a boat for each day period (morning and evening strata). Angler count dates and times were selected randomly. Angler interviews were conducted following the completion of each instantaneous count. Anglers were asked how many fish they had harvested and/or released by species, how many hours they had fished, what their preferred target species was, whether or not they were aware of the Redfish Lake kokanee fishery, and the type of gear they used. All responses were recorded by creel personnel. Fin clips were taken from harvested kokanee that were checked by creel survey personnel. Fin clips were stored in 100% ethanol and delivered to IDFG Genetics Laboratory personnel for DNA analysis. Creel data were analyzed using the Creel Application Software computer program developed by Soupier and Brown (2002) and used to estimate angler effort, catch rates, and harvest.

## **RESULTS AND DISCUSSION**

### **Oncorhynchus nerka Population Monitoring**

#### **Redfish Lake**

October trawl catch on Redfish Lake (six transects, Appendix A) included 25 natural origin *O. nerka* and zero hatchery origin (adipose fin-clipped) sockeye salmon. *Oncorhynchus nerka* abundance was estimated at 30,194 fish (95% CI  $\pm$  16,139). The *O. nerka* population was up 4% (within Redfish Lake) from the estimated abundance levels in 2009 (28,923 fish) and increased 15% from the estimated abundance of *O. nerka* for 2008 (26,284; Table 6).

Density and biomass were estimated at 49.1 fish/ha and 0.16 kg/ha, respectively (Table 6). This represented increases of 4% for densities and 45% in biomass from estimated levels in 2009 (Peterson et al. 2011). Age-0 and age-2 *O. nerka* were represented in the trawl sample from

Redfish Lake. Age-0 fish had the highest density (46.8 fish/ha) and the highest biomass (0.09 kg/ha; Table 7).

### **Alturas Lake**

October trawl catch on Alturas Lake (six transects, Appendix A) included 21 natural origin *O. nerka* and zero hatchery origin (adipose fin-clipped) sockeye salmon. We estimated *O. nerka* abundance, density, and biomass at 10,366 fish (95% CI  $\pm$  8,047), 30.7 fish/ha, and 1.42 kg/ha, respectively (Table 6). Age-0, age-1, age-2, and age-3 *O. nerka* were represented in the trawl sample. Age-3 fish had the highest density (10.24 fish/ha) and contributed 32% of the biomass (Table 7). The estimates for abundance, density, and biomass were 74% lower, 74% lower, and 59% lower than 2009 estimates, respectively (Table 6).

### **Pettit Lake**

October trawl catch on Pettit Lake (six transects, Appendix A) included 26 natural origin *O. nerka* and zero hatchery origin (adipose fin-clipped) sockeye salmon. We estimated *O. nerka* abundance, density, and biomass at 13,246 fish (95% CI  $\pm$  5,961), 82.8 fish/ha, and 0.57 kg/ha, respectively (Table 6). Age-0, age-1, and age-2 fish were represented in the trawl sample. Age-1 fish had a density of 44.6 fish/ha and a biomass of 0.30 kg/ha (Table 7). The estimates for abundance, density, and biomass were 186% higher, 106% higher, and 612% higher than 2009 estimates, respectively.

Kokanee control within the three nursery lakes has proven to be difficult because of many factors such as weir failure, otter damage to weirs and traps, and the lack of a permanent sill structure (A. Kohler, Shoshone Bannock Tribes, personal communication). We experience high levels of adult escapement variation in both Fishhook Creek and Alturas Lake Creek (Table 8), which appears to cause population fluctuations within these systems. Recent genetic findings from both trawl and angler caught samples suggest that the Pettit Lake residual sockeye population may be increasing and the nonnative kokanee population may actually be decreasing, although results are not statistically significant (Chris Kozfkay, IDFG, personal communication). Potential behavioral differences between nonnative kokanee and sockeye may account for some of the population changes that occurred between 2009 and 2010. Pettit Lake is also very difficult to sample due to its relatively small size compared to the other two nursery lakes. Zooplankton abundance levels have remained high enough for *O. nerka* growth to occur within each lake (R. Griswold, Bio-Lines, personal communication). *O. nerka* abundance monitoring should remain a priority for the program to monitor zooplankton abundance and help us to develop escapement goals, which are necessary to minimize kokanee and zooplankton population fluctuations. These goals should also provide a stable nursery habitat environment for sockeye salmon by reducing competition between kokanee and sockeye. Escapement goals should be discussed annually before kokanee enter the tributaries to spawn and recommendations presented to the SBSTOC for discussion and modification.

### **Genetic Results From Trawl Samples**

In 2010, tissues for genetic analysis were collected from 72 *O. nerka* during the midwater trawling events performed by IDFG personnel. These samples were delivered to the IDFG Eagle Fish Genetics Laboratory (Eagle, Idaho) for microsatellite DNA analysis, and the results of the analysis are listed below.

## **Redfish Lake**

In 2010, 25 fin samples were analyzed from trawl captured *O. nerka* on Redfish Lake and 13 had genotypes indicative of protected Snake River sockeye salmon (54% with 95 % confidence bounds ranging from 35% to 72%).

## **Pettit Lake**

In 2010, 26 fin samples were analyzed from trawl captured *O. nerka* on Pettit Lake and 23 had genotypes indicative of protected Snake River sockeye salmon (89% with 95 % confidence bounds ranging from 71% to 96%).

## **Alturas Lake**

In 2010, 21 fin samples were analyzed from trawl captured *O. nerka* on Alturas Lake and none of the sample fish had genotypes indicative of protected Snake River sockeye salmon.

We will continue to monitor these populations utilizing microsatellite DNA analysis.

### **Redfish Lake Sport Fishery Investigations**

In 2010, we contacted 29 angler parties (58 individual anglers) on Redfish Lake. Idaho residents made up 93.6% of those interviewed. Most anglers used lures (63.5%), followed by bait (31.7%). Total angler effort was estimated at 2,816 hours (95% CI  $\pm$  2,185; Table 9). This effort estimate represents a 131% increase in fishing pressure between 2009 and 2010 (Table 10). Boat anglers expended more effort (55%) than bank anglers (38%), which was similar to results from 2009 (Peterson et al. 2011).

The season catch rate for all fish (caught) was 1.08 fish/hour. Catch rates increased 40% over the estimate from 2009 (Peterson et al. 2011). Kokanee catch rates (harvested and released) averaged 0.06 kokanee/hour for weekdays and 0.00 kokanee/hour for weekends (Table 11); the 2010 season estimate of 0.02 kokanee/hour kept was 200% higher than the 2009 season estimate of 0.00 kokanee/hour. Bull trout catch and release rates averaged 0.10 bull trout/hour for weekdays and 1.08 bull trout/hour for weekends (IDFG regulations prohibit harvesting bull trout; Table 11). We also estimated that 2,064 bull trout were caught and released from Redfish Lake during 2010 (Table 12). The season catch rate for bull trout is higher than observed rates from 2008 and 2009 (0.08 and 0.54 bull trout/hour, respectively). Creel trend data suggests an overall increase in bull trout catch rates since the closure to harvest in 1994 (Figure 2); this trend will be discussed further in Part 4 of this report under Predator Surveys. Cutthroat trout had catch rates of 0.23 fish/hour released for the season.

The total number of fish caught (harvested and released) in Redfish Lake was estimated at 3,039 fish (95% CI  $\pm$  156). This was an overall increase of 301% from the 2009 estimate. The majority (98.1%) of all fish caught were released. Kokanee harvest was estimated at 57 fish (95% CI  $\pm$  10) and the number of kokanee released was estimated at zero (95% CI  $\pm$  0; Table 12). We are currently investigating the idea of reestablishing a rainbow trout fishery in Redfish Lake. Creel data from 1986 and 1987 (Reingold and Davis 1987; Davis and Reingold 1988) suggests that a rainbow trout fishery within Redfish Lake could produce between 12,000-15,000 hours of effort and provide a potential increase in the number of kokanee caught and harvested as by-catch to the fishery.

No hatchery-produced sockeye salmon (adipose-clipped) were observed by creel personnel during 2010. The direct impact of the kokanee fishery on residual sockeye salmon (through incidental harvest) is evaluated annually using genetic analysis of tissue samples collected from kokanee in the creel. However, creel clerks did not collect tissue samples for genetic analysis during 2010. Assuming that ESA-listed sockeye salmon (marked and unmarked) represent approximately 13.5% of the total number of *O. nerka* available to the sport fishery in Redfish Lake (based on the average proportion of sockeye from microsatellite analyses of creel captured sample in 2006 and 2008 conducted by the Idaho Fish and Game Eagle Genetics Lab), a total of up to 18 ESA-listed fish were potentially impacted by the 2010 sport fishery (Redfish Lake: 57 kokanee kept  $\times 0.135 = 8$  and 57 kokanee kept  $\times .32$  [upper 95% bound] = 18). This is likely an overestimate based on our knowledge of fishing pressure and where kokanee are captured within the lake.

Table 6. Estimated *O. nerka* population, density, and biomass for Redfish, Alturas, and Pettit lakes, 1990 to 2010.

Year	Population ( $\pm$ 95% CI)	Density (fish/ha)	Biomass (kg/ha)
<b><u>Redfish Lake (615 surface hectares)</u></b>			
2010	30,194 (16,139)	49.1	0.16
2009	28,923 (32,197)	47.0	0.11
2008	26,284 (13,226)	42.7	0.29
2007	73,702 (24,195)	119.8	0.84
2006	82,796 (47,407)	134.6	2.37
2005	56,220 (4,192)	91.4	0.3
2004	82,258 (3,486)	133.0	0.3
2003	81,727 (2,763)	132.9	1.6
2002	50,204 (4,085)	81.6	1.0
2001	12,980 (2,959)	21.1	<0.1
2000	10,268 (1,605)	16.7	<0.1
1999	42,916 (1,795)	69.7	0.9
1998	31,486 (1,716)	51.2	1.8
1997	55,762 (1,590)	90.7	2.5
1996	56,213 (3,526)	91.4	2.8
1995	61,646 (2,078)	100.2	4.4
1994	51,529 (4,902)	83.8	1.4
1993	49,628 <sup>a</sup>	80.7	1.6
1992	39,481 (2,498)	64.2	1.0
1990	24,431 (11,000)	39.7	0.8
<b><u>Alturas Lake (338 surface hectares)</u></b>			
2010	10,366 (8,047)	30.7	1.42
2009	39,781 (11,697)	117.7	3.50
2008	71,088 (34,189)	210.3	2.67
2007	124,073 (23,327)	367.1	3.43
2006	105,779 (50,702)	313.0	3.51
2005	20,956 (2,136)	98.8	0.3
2004	36,206 (2,579)	107.1	1.9
2003	46,234 (5,183)	136.8	5.5
2002	24,374 (2,328)	72.1	2.2
2001	70,159 (1,696)	207.6	2.4
2000	125,462 (1,572)	371.0	2.1
1999	56,675 (4,476)	167.7	0.4
1998	65,468 (2,860)	193.7	1.4
1997	9,761 (933)	28.9	2.1
1996	13,012 (691)	38.5	1.4
1995	23,061 (1,202)	68.2	1.7
1994	5,785 (1,957)	17.1	0.4
1993	49,037 (1,443)	145.1	2.6
1992	47,237 (3,782)	139.8	2.4
1991	125,045 (1,881)	370.0	3.9
1990	126,644 (1,690)	374.7	3.3

Table 6. Continued.

Year	Population ( $\pm$ 95% CI)	Density (fish/ha)	Biomass (kg/ha)
<b>Pettit Lake (160 surface hectares)</b>			
2010	13,246 (5,961)	82.8	0.57
2009	4,623 (4,536)	40.2	0.08
2008	8,470 (4,640)	52.9	1.28
2007	14,746 (7,099)	92.2	3.84
2006	33,246 (12,416)	207.8	7.4
2005	23,970 (2,136)	149.8	2.2
2004	46,065 (3,288)	287.9	9.8
2003	11,961 (626)	136.8	5.5
2002	18,328 (384)	114.5	12.1
2001	16,931 (1,311)	105.8	6.1
2000	40,559 (1,317)	253.5	10.2
1999	31,422 (2,515)	196.4	6.3
1998	27,654 (862)	172.8	9.7
1997	21,730 (1,462)	135.8	5.1
1996	71,654 (911)	447.8	15.3
1995	59,002 (1,653)	368.8	14.7
1994	14,743 (1,966)	92.1	3.1
1993	10,511 (640)	65.7	0.8
1992	3,009 (539)	18.8	2.5

<sup>a</sup> Confidence limits not calculated—single transect estimate.

Table 7. Estimated 2010 *O. nerka* abundance, density (fish/ha), and biomass (kg/ha) by age class in Redfish, Alturas, and Pettit lakes.

	Age-0	Age-1	Age-2	Age-3	Age-4	Total
<b>Redfish Lake (615 surface ha)</b>						
No. captured	24	0	1	0	0	25
Mean length (mm) ( $\pm 95$ CI)	60.7	NA	150	NA	NA	105.35
Mean weight (g) ( $\pm 95$ CI)	1.93	NA	32.7	NA	NA	17.3
Abundance	28,814	NA	1,380	NA	NA	30,194
95% CI High	43,025	NA	4,928	NA	NA	46,333
95% CI Low	14,603	NA	0	NA	NA	14,055
Density (fish/ha)	46.8	NA	2.24	NA	NA	49.1
Biomass (kg/ha)	0.09	NA	0.07	NA	NA	0.16
<b>Alturas Lake (338 surface ha)</b>						
No. captured	9	3	6	3	0	21
Mean length (mm) ( $\pm 95$ CI)	69	114	199	205	NA	146.8
Mean weight (g) ( $\pm 95$ CI)	3.06	13.8	82.8	92.6	NA	48.06
Abundance	3,449	1,736	3,461	1,722	NA	10,366
95% CI High	6,701	4,811	9,209	3,395	NA	18,413
95% CI Low	197	0	0	49	NA	2,319
Density (fish/ha)	10.2	4.47	5.09	10.24	NA	30.7
Biomass (kg/ha)	0.027	0.071	0.86	0.46	NA	1.42
<b>Pettit Lake (115 surface ha)</b>						
No. captured	11	14	1	0	0	26
Mean length (mm) ( $\pm 95$ CI)	69.5	88.7	160	NA	NA	120.15
Mean weight (g) ( $\pm 95$ CI)	3.4	6.8	46.2	NA	NA	10.30
Abundance	5,595	7,135	515	NA	NA	13,246
95% CI High	7,984	11,511	1,837	NA	NA	19,207
95% CI Low	3,206	2,759	0	NA	NA	7,285
Density (fish/ha)	34.9	44.6	3.22	NA	NA	82.8
Biomass (kg/ha)	0.12	0.30	0.15	NA	NA	0.57

Table 8. Estimated kokanee escapement to Fishhook Creek 1991 to 2010 and Alturas Lake Creek 1992 to 2010. Data obtained from the Shoshone-Bannock Tribes.

<b>Year</b>	<b>Fishhook Creek</b>	<b>Alturas Lake Creek</b>
1991	7,200	No survey data
1992	9,600	60
1993	10,800	200
1994	9,200	3,200
1995	7,000	1,600
1996	10,662	744
1997	8,572	8,492
1998	6,149	15,237
1999	2,336	8,334
2000	60	827
2001	5,853	145
2002	8,626	99
2003	9,679	48
2004	1,508	7,101
2005	4,375	11,652
2006	14,021	2,276
2007	11,235	519
2008	4,908	10,312
2009	1,796	1,627
2010	1,708	4,927

Table 9. Estimated angler effort on Redfish Lake for the 2010 fishing season.

<b>Redfish Lake</b>	<b>Boat</b>	<b>Bank</b>	<b>Tube</b>	<b>Total</b>
Estimated Hours fished	2,076	709	31	2,816
± 95%	2,085	394	74	2,185

Table 10. Historical kokanee catch rates, kokanee harvest estimates, bull trout catch rates, and angler effort for the Redfish Lake fishery.

	<b>Kokanee Catch Rates (Fish/Hour)</b>		<b>Kokanee Harvested</b>	<b>Bull Trout Catch Rate (Fish/Hr)</b>	<b>Angler Parties Interviewed</b>	<b>Estimated Hours Fished/Season</b>
	<b>Harvested (Fish/Hour)</b>	<b>Released (Fish/Hour)</b>				
1996	0.19	0.08	844	0.09	107	3,351
1997	0.19	0.37	466	0.08	117	2,874
1998	0.13	0.17	1,362	0.08	205	7,963
1999	0.38	0.15	1,187	0.28	227	3,951
2000	0.02	0.06	67	0.08	63	3,063
2001	0.00	0.06	0	0.27	88	2,391
2002	0.09	0.16	129	0.16	100	2,127
2003	0.10	0.05	424	0.24	98	2,477
2004	0.13	0.26	621	0.31	96	2,791
2005	0.21	0.09	637	0.09	85	3,620
2006	0.07	0.24	222	0.35	131	2,635
2007	0.03	0.09	56	0.12	53	1,922
2008	0.05	0.04	106	0.08	41	2,424
2009	0.00	0.00	0	0.55	32	1,219
2010	0.02	0.00	57	0.73	58	2,816

Table 11. Catch rates (fish/hour) for summer 2010 on Redfish Lake categorized by day type and species.

<b>Day Type</b>	<b>Kokanee</b>		<b>Cutthroat Trout</b>		<b>Bull Trout</b>		<b>All Fish</b>	
	<b>Kept</b>	<b>Released</b>	<b>Kept</b>	<b>Released</b>	<b>Kept</b>	<b>Released</b>	<b>Kept</b>	<b>Released</b>
Weekday	0.06	0.00	0.00	0.00	0.00	0.10	0.06	0.10
Weekend day	0.00	0.00	0.00	0.36	0.00	1.08	0.00	1.59
Season Avg.	0.02	0.00	0.00	0.23	0.00	0.73	0.02	1.06

Table 12. Estimated number of fish harvested and released on Redfish Lake during summer 2010.

<b>Redfish Lake</b>	<b>Kokanee</b>	<b>Cutthroat Trout</b>	<b>Bull Trout</b>	<b>Other</b>	<b>All Fish <math>\pm</math> 95% CI</b>
Harvested	57	0.00	0	0	57 $\pm$ 10
Released	0	0.00	2,064	269.8	155 $\pm$ 2,981.9

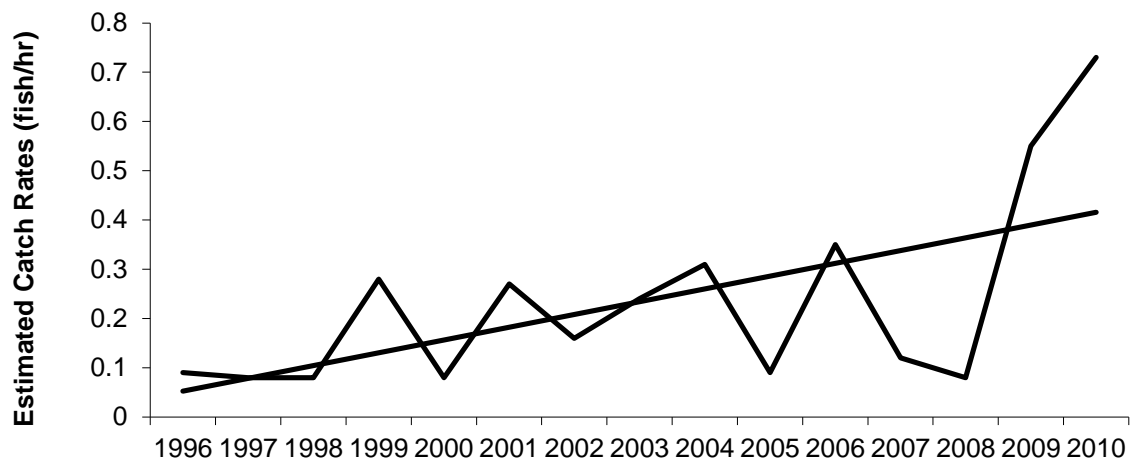


Figure 2. Estimated bull trout catch rates from 1996-2010 within Redfish Lake. The trend line is used to show the catch rate increase within the lake. The equation for the trend line is  $y = 0.0259x + 0.0266$  with an  $R^2$  of 0.360.

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## **PART 3—SOCKEYE SALMON JUVENILE OUT-MIGRANT AND ADULT SPAWNING MONITORING AND EVALUATION**

### **INTRODUCTION**

#### **SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION**

Monitoring overwinter survival and out-migration of sockeye salmon smolts plays an important role in restoration efforts. Trapping conducted on the lake outlet streams provides information on timing of out-migration and smolt sizes. Out-migrant monitoring provides an opportunity to monitor natural production of sockeye salmon in the lakes and to evaluate the success of different release strategies. This information allows us to make informed decisions regarding the placement of future captive broodstock progeny.

Out-migrant trapping also provides overwinter survival information for presmolts (fall direct-release) released into the nursery lakes in October the year prior to out-migrant trapping. Hatchery origin sockeye salmon smolts captured at lake out-migrant traps originated primarily from the October 2009 release of adipose fin-clipped presmolts numbering 34,561 sockeye, 9,994 sockeye, and 14,983 sockeye to Redfish, Alturas, and Pettit lakes, respectively (Table 13). All presmolts released in 2009 were reared at Sawtooth Fish Hatchery (SFH).

#### **ADULT SPAWNING MONITORING AND EVALUATION**

Releasing mature adult sockeye salmon into Sawtooth Valley lakes has been an important part of the "spread-the-risk" philosophy of the SBSTOC. Prespawn sockeye salmon adults were first released back to the wild in 1993. Adult sockeye salmon raised to maturity in the hatchery and released to valley lakes to spawn provide a "natural" or unmarked smolt component that is subject to natural selection. Beginning in 1999, hatchery origin anadromous sockeye salmon have been released into valley lakes (when available) along with adult sockeye salmon that were raised to maturity in a hatchery. Currently, prespawn adults are released only to Redfish Lake.

Success of releasing adults to spawn naturally is evaluated by determining if there is a corresponding increase in production in the number of natural smolts out-migrating and observed egg-to-smolt survival (within Redfish Lake currently). Natural out-migrants can be progeny of residual sockeye salmon adults that spawn in basin lakes; hatchery origin prespawn adults released to the lakes for natural spawning (Redfish Lake only); anadromous adults released to the lakes for natural spawning (Redfish Lake only); eyed egg releases (Alturas or Pettit Lakes); or misclipped hatchery origin smolts. Juvenile kokanee (nonanadromous) could also "fall out" of nursery lakes and contribute to adult trap counts. The weirs on Redfish Lake Creek and Pettit Lake Creek and the screw trap on Alturas Lake Creek enable us to monitor and estimate natural out-migrating smolts and obtain genetic samples.

Current evaluations of adult sockeye salmon releases focus on the number of redds produced and estimations of unmarked juvenile out-migrants and collection of genetic material for future DNA parental exclusion analysis.

## METHODS

### SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION

#### Redfish Lake Creek Trap

The out-migrant trap on Redfish Lake Creek (RLCTRP) is located 1.4 km downstream from the lake outlet at a permanent weir site. The trap functions as a juvenile trap for out-migrating fish, and with minor modifications, as a trap for returning adults (Craddock 1958; Bjornn et al. 1968; Kline 1994; Kline and Younk 1995; Kline and Lamansky 1997; Hebdon et al. 2000, 2002, 2003; Willard et al. 2004, 2005; Peterson et al. 2008, 2010, 2011). The trap was operated from April 10 through June 16, 2010 and contains nine bays, five of which were fitted with incline bar traps. IDFG staff checked the trap twice daily in 2010. The trap is fished until high water forces us to remove it, until fish stop emigrating from the lake, or until mid-June (contract deadline for removal of trap and the placement of the adult trap).

Each fishing bay was fitted with an adjustable 1.70 m wide by 1.74 m long aluminum trap box on a winch and pulley system. The trap boxes were constructed of 3 mm aluminum sheeting and framework and 1.9 cm diameter hollow aluminum bars. The 30.5 cm x 169.5 cm x 30.5 cm. live wells were also constructed of 3 mm aluminum with 5 mm holes drilled for aeration and water exchange in the live well. Bar spacing (19 mm) allowed debris and large fish to pass downstream, while low velocity water swept *O. nerka* smolts across the bars and into the live well for holding until personnel were able to empty the trap (Kline 1994).

All sockeye salmon smolts captured at RLCTRP were anesthetized in buffered tricaine methanesulfonate (MS-222; 50 mg/L), measured for fork length (1 mm), weight (0.1 g), and scanned for PIT tags. Scales were removed from a subsample of natural origin and adipose fin-clipped hatchery reared *O. nerka* (five fish from each 5 mm length group) and returned to the laboratory for aging. In the lab, scales were pressed between microscope slides, two program employees individually aged the scales, and a third person aged the discrepancies. The proportions of age-1 and age-2 out-migrants were determined by using the MIX computer program developed by MacDonald and Green (1988). MIX software uses known values (the scale ages in this case) and fits mixture distributions to grouped data by utilizing a maximum likelihood estimator. All captured nontarget species were counted and released immediately. Fin-clip samples were taken from up to 50 wild smolts/day for future genetic analyses (Redfish Lake = 1,159, Alturas Lake = 0, Pettit Lake = 225).

To estimate trapping efficiency, up to 20 natural origin sockeye salmon smolts (determined by presence of an adipose fin) and 20 hatchery origin sockeye salmon smolts were PIT tagged daily and released approximately 250 m upstream of the weir one-half hour after sunset. All remaining fish were identified (natural origin and hatchery origin), scanned for PIT tags, counted, and released 15 m below the weir one-half hour after sunset. Flow-through live boxes with locking lids were used to hold fish until the evening release. Trapping efficiencies were calculated for natural origin sockeye salmon smolts and fall direct-released sockeye salmon smolts. Intervals were selected based on stream discharge similarities and the number of PIT-tagged smolts released upstream of the weir that were available for recapture (trap efficiencies). Natural origin fish typically out-migrate earlier in the season than fall direct-release fish (Figure 3). Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from the 34,561 adipose fin-clipped presmolts (reared at SFH) released into the lake in October 2009 (Table 4). Stream velocity was measured below the trap weekly. Out-migrant run size was derived using a modified Bailey estimator and 95% bootstrap confidence intervals

using methods described by Steinhorst et al. (2004). Smolt out-migration estimates were calculated separately for natural origin and fall direct-released hatchery origin sockeye salmon smolts. During the spring of 2010, we experienced normal flow conditions throughout the trapping season.

#### **Alturas Lake Creek Trap**

Sockeye salmon out-migrant trapping and PIT tagging on Alturas Lake Creek was conducted by the SBT. The Alturas Lake Creek screw trap is located 13 km downstream from the Alturas Lake outlet and was operated from April 20 to June 1, 2010. Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from 9,994 adipose fin-clipped presmolts (reared at EFH) released into the lake in July 2009 (Table 4). The Alturas Lake out-migrant population estimate was derived using the same estimator described above (Steinhorst et al. 2004) except under extreme flow conditions when other methods are used to estimate out-migrant numbers. Activities conducted by the Shoshone-Bannock Tribes are reported under separate cover.

#### **Pettit Lake Creek Trap**

Sockeye salmon out-migrant trapping and PIT tagging on Pettit Lake Creek was conducted by the SBT. The Pettit Lake Creek trap is located 1 km downstream from the Pettit Lake outlet at a permanent weir site and was operated from April 21 to May 22, 2010. Hatchery-produced sockeye salmon smolts captured at the trap originated primarily from the 14,983 adipose fin-clipped presmolts (reared at SFH) released into the lake in October 2009 (Table 4). The Pettit Lake Creek weir traps at 100% efficiency under low spring flow conditions (D. Taki, Shoshone Bannock Tribes, personal communication); therefore, out-migration run size for Pettit Lake is based on the actual number of smolts trapped. However, during normal to high flow years, the trap must be removed and other means are used to estimate the number of out-migrants. Activities conducted by the Shoshone-Bannock Tribes are reported under separate cover.

#### **Salmon River and Redfish Lake Creek Smolt Groups**

A total of 118,780 BY08 smolts were released near the river water intake of SFH on May 4<sup>th</sup>, 2010 (Table 13). This release included smolts reared at Sawtooth Fish Hatchery (SFH) and Oxbow Fish Hatchery (OFH). All fish released were coded-wire-tagged, with a representative group (n = 31,793) PIT tagged.

A total of 60,498 BY08 smolts were released into Redfish Lake Creek below the out-migrant weir on May 4<sup>th</sup>, 2010 (Table 13). This release group originated from smolts reared at OFH and Sawtooth Fish Hatchery (SFH). All fish were coded-wire-tagged with a representative group (n = 31,813) PIT tagged.

#### **Main Stem Snake and Columbia River Dams**

In 2010, sockeye salmon smolts were transported and released below Bonneville Dam according to a USACE PIT tag study (methods and results can be found in BioMark and Quantitative Consultants, Inc. 2010). As a result, main stem survival evaluations were only conducted to Lower Granite Dam (LGR) for this project. Sockeye salmon smolt survival to LGR was evaluated using PIT tag interrogation data collected at PIT tag detection facilities throughout the Snake and Columbia rivers. Interrogation data were retrieved from the PIT tag

information system (PTAGIS) maintained by the Pacific States Marine Fisheries Commission (Portland, Oregon). This data was used to develop SURPH survival estimates to LGR. The SURPH model uses PIT tag detections at various dams to develop a Cormack/Jolly-Seber estimate of survival to LGR. Total natural origin and hatchery origin smolt out-migration (for each lake and different release strategy) to LGR was estimated using the SURPH survival estimate (for each respective release group) multiplied by the out-migration estimate of each release group at the out-migration trap sites found in the Stanley basin (Table 13).

## **ADULT SPAWNING MONITORING AND EVALUATION**

### **Sockeye Salmon Spawning Investigations**

Between August 8 and September 17, 2010, 1,582 adult sockeye salmon were released to Redfish Lake (Table 5). Adult releases included 1,210 anadromous return adults, 198 adults raised at NOAA Burley Creek Hatchery, and 174 Eagle Fish Hatchery adult fish. Sex was determined by ultrasound on hatchery adults and efforts were made to release fish of equal sex ratios.

In order to assist in identifying spawning locations, five male and five female hatchery-produced, and five male and five female anadromous return sockeye salmon were fitted with gastric implant radio transmitters prior to release. Telemetry investigations of adult locations began September 21, 2010 and continued weekly through November 12, 2010. Fish locations were recorded weekly by tracking movements via powerboat.

Redd counts were also conducted once a week (coinciding with radio telemetry events) beginning on October 27, 2010 and continuing until November 15, 2010. Suspected redds were generally enumerated by two observers on each count date. On the final count date, three observers were used. Areas of excavation (possible redds) were generally 3 m x 3 m in size and likely represented spawning events by multiple parents. As such, we do not know how many parents contributed to the production of natural progeny in spawn year 2010. During redd count surveys any observed carcasses that could be retrieved were collected to facilitate the collection of biological information (e.g., fish sex and spawning status). We also performed redd counts on Little Redfish Lake in 2010.

### **Natural Origin Juvenile Out-migrant Monitoring**

In 2010, natural origin out-migrants produced from program fish releases to Redfish Lake included: 1) age-1 out-migrants produced from 969 adults released for volitional spawning in 2008 2) age-2 out-migrants produced from 494 hatchery-origin adults released in 2007. Any age-1 or age-2 natural origin out-migrants would have been produced by residual sockeye or kokanee found within Alturas Lake (no eyed egg releases to Alturas Lake in 2007 or 2008). Natural origin out-migrants produced from program fish releases to Pettit Lake included age-2 out-migrants from 51,008 eyed eggs released in 2007, and age-1 out-migrants produced from 67,984 eyed eggs released in 2008. The proportions of age-1 and age-2 natural origin emigrants were determined for 2010 Redfish, Alturas, and Pettit lake out-migrants by aging scales. The methods for this analysis are discussed above.

### **Adult Trapping on Redfish Lake Creek**

The adult weir on Redfish Lake Creek captures all upstream migrating sockeye salmon and bull trout. Trapping in Redfish Lake Creek for adult migrants started on July 16 and continued until October 21, 2010. During the operation of the adult sockeye salmon weir on Redfish Lake Creek in 2010, 651 adult anadromous sockeye and 187 adult bull trout were captured.

## **RESULTS AND DISCUSSION**

### **SOCKEYE SALMON JUVENILE OUT-MIGRANT MONITORING AND EVALUATION**

#### **Redfish Lake Creek Trap**

A total of 7,422 sockeye salmon smolts (4,446 natural origin and 2,976 hatchery origin) were trapped during the 2010 out-migration season (Figure 3 and Table 14). Fork length of natural origin and hatchery origin sockeye salmon smolts captured averaged 108 mm (range 86 mm to 180 mm; Figure 4) and 107 mm (range 85 mm to 149 mm; Figure 4), respectively. Sockeye salmon smolt lengths were slightly shorter for natural origin and slightly longer for hatchery origin in 2010 than during the 2009 out-migration season (Peterson et al. 2011).

Based on observed trapping efficiencies and discharge during out-migration monitoring, we determined that using one trapping interval for the natural origin smolts was appropriate for estimating total natural origin sockeye salmon smolt out-migration. Of the 4,446 natural origin smolts handled in 2010, 727 were marked and released upstream of the weir to estimate trapping efficiency.

Trap efficiency decreased from a five-year average (2001-2005) of 42% to 32% during 2010. This was likely due to predation at the trap by small mammals, piscivorous birds, bull trout and probably not due to the high flows observed. Several personnel visually observed hooded mergansers and bull trout harassing juvenile sockeye at the trap. The artificial decrease in trap efficiency would have caused us to overestimate the number of natural out-migrants. During 2010, we continued our capture and haul program to remove bull trout from the juvenile trap site so we can develop better out-migration estimates at the Redfish Lake Creek trap.

The 2010 total natural origin sockeye smolt out-migration was estimated at 14,012 fish (95% CI 12,615-15,621; Table 14). The proportion of age-1 natural origin smolts was estimated at 88%, which equals 12,331 smolts; the proportion of age-2 natural origin smolts was estimated at 12%, which equals 1,681 smolts. As referenced in the Methods section of this report, age proportions were estimated using the MIX software application.

Of the 2,976 fall direct-released smolts handled in 2010, 614 were marked and released upstream of the weir to estimate trap efficiency. Total fall direct-released smolt out-migration was estimated at 5,972 fish (95% CI 5,499–6,532; Table 14). Overwinter survival and out-migration for this group was 17.2% of the number of presmolts planted in 2009 (Table 15). The proportion of age-1, adipose fin-clipped, hatchery-reared smolts was estimated at 95%, which equals 5,673 smolts; the proportion of age-2, adipose fin-clipped, hatchery-reared smolts was estimated at 5%, which equals 299 smolts.

### **Alturas Lake Creek Trap**

A total of 134 sockeye salmon smolts (8 natural origin and 126 hatchery origin) were trapped during the 2010 out-migration season. Fork length of natural origin and hatchery origin sockeye salmon smolts captured averaged 99 mm (range 85 mm to 117 mm) and 103 mm (range 79 mm to 121 mm), respectively. The average size of out-migrating sockeye smolts was similar to 2009 (Peterson et al. 2011).

Total natural origin sockeye smolt out-migration for Alturas Lake was estimated at 45 fish (95% CI not calculated), and hatchery origin smolt out-migration was estimated at 899 fish (95% CI 719–1,079; see SBT annual report for methods and calculations; Table 13). Genetic samples were collected from out-migrating sockeye smolts to identify the source of out-migrants (whether these fish were produced by kokanee or residual sockeye). Overwinter survival and estimated outmigration for the fall direct-release group was 9% of the number of presmolts planted in 2009 (Table 15). Due to the limited number of out-migrants, we were not able to estimate the age proportion of natural origin and hatchery origin sockeye smolts for Alturas Lake in 2010.

### **Pettit Lake Creek Trap**

Total natural origin sockeye smolt out-migration for Pettit Lake in 2010 was estimated at 3,476 fish (95% CI 2,936–4,016) and hatchery origin smolt out-migration was estimated at 3,634 fish (95% CI 2,736–4,532); see SBT annual report for methods and calculations; Table 13). Overwinter survival and out-migration for fall 2009 direct-released presmolts was 24% (Table 15). Fork length of natural origin and fall direct-released sockeye salmon smolts captured averaged 121 mm (range 105 mm to 186 mm) and 112 mm (range 96 mm to 184 mm), respectively. Natural origin and hatchery origin sockeye smolt age proportions were not estimated because scale samples were not collected from these smolts during the 2010 trapping season.

### **Salmon River and Redfish Lake Creek Smolt Groups**

We released 60,498 BY08 smolts into Redfish Lake Creek below the out-migrant weir on May 4, 2010. This release group consisted of smolts reared at Oregon Department of Fish and Wildlife Oxbow FH (n = 34,619) and Sawtooth Fish Hatchery (n = 25,879). All fish released were coded-wire-tagged with a representative group (n = 31,813) PIT tagged. Sawtooth Hatchery smolts had an average fork length of 103 mm (range 78 mm to 123 mm) and an average weight of 11.1 g/fish. The smolts of Oxbow Fish Hatchery averaged 142 mm (range 111 mm to 169 mm) in fork length and had an average weight of 29.5 g/fish.

A total of 118,780 BY08 smolts were released into the Salmon River below the Sawtooth FH river water intake upstream of the weir on May 4, 2010. This release included smolts reared at Sawtooth FH (n = 73,513) and Oxbow FH (n = 45,267). All fish were coded-wire-tagged with a representative group (n = 31,793) PIT tagged. The average lengths and weights of the Salmon River smolt group from Sawtooth FH and Oxbow FH were the same as above. Warmer rearing water temperatures at Oxbow FH contribute to the consistently larger smolt size than those of Sawtooth FH smolts.

## **Main Stem Snake and Columbia River Dams**

We estimated smolt out-migration success to LGR for natural origin and hatchery origin sockeye salmon smolt groups using PIT tag interrogation data (Table 13; Appendix B). Estimates reflect numbers of smolts that arrived at LGR based on results from data analyses using the SURPH model (Table 13). Survival among release groups ranged from 15% (Redfish Lake Creek hatchery origin smolts) to 44% (Alturas Lake hatchery fall direct release smolts). The average survival rate for all the release groups was 27% to LGR (down from 50% survival in 2009; Peterson et al. 2011). An estimated 4,764 (34% survival) and 1,851 (31% survival) natural origin and fall direct-release sockeye smolts, respectively, survived to LGR from the Redfish Lake Creek trap. Survival from the Alturas Lake Creek trap to LGR was not estimated due to low recapture rates for natural origin smolts and was estimated at 396 (44% survival) for fall direct-release smolts. Survival from the Pettit Lake Creek trap to LGR was estimated at 869 (25% survival) for natural origin smolts and 1,272 (35% survival) for fall direct-release smolts. An estimated 11,317 (25% survival) smolts from Oxbow FH and 11,762 (16% survival) Sawtooth FH sockeye smolts survived to LGR from the Salmon River smolt release group. From the Redfish Lake Creek smolt release group an estimated 5,885 (17% survival) Oxbow FH smolts and 3,882 (15% survival) Sawtooth FH smolts survived to LGR. The total estimate for sockeye smolts that out-migrated from Stanley Basin waters and survived to LGR for 2010 was 41,998 (Table 13).

This was the fifth year we used the SURPH model to estimate survival and numbers of smolts to LGR. We will continue to utilize the SURPH model to develop survival and total estimates to LGR; however, we are beginning to examine the lack of PIT tag detection capabilities on the removable spillway weirs (RSWs) located on the Lower Snake River dams and their effects on our survival estimates. We hypothesize that many of our PIT-tagged smolts were not detected at the Lower Snake dams but were flushed down the system over the RSWs. PIT tag interrogation data indicates that a greater number of smolts were detected at Bonneville Dam (a low interrogation efficiency site) than at LGR (a high interrogation efficiency site), which would potentially cause us to underestimate survival to LGR. We will gain a better idea of how the lack of detection equipment affects our survival estimates when the juveniles return as adults during the return years of 2011, 2012, and 2013. If we see similar smolt-to-adult return rates back to the basin, we can assume that we underestimated survival to LGR as juveniles.

## **SOCKEYE SALMON SPAWNING INVESTIGATIONS AND NATURAL ORIGIN JUVENILE OUT-MIGRANT MONITORING**

### **Sockeye Salmon Spawning Investigations**

A total of 1,582 prespaw adult sockeye (372 full-term captive reared and 1,210 anadromous return) salmon were released into Redfish Lake in 2010. The first redd was observed near Sockeye Beach at Redfish Lake on September 21, 2010. Redd counts were finalized with three observers in one boat on November 15. Redd construction timing was similar to observations made in the past (Plaster et al. 2007, Peterson et al. 2008, 2010, 2011). During the final counts, 155 redds (areas of excavation) were identified (Table 16). Twenty redds were located near the U.S. Forest Service Transfer dock, 36 redds were located on the beach southeast of the Redfish Lake Creek inlet, 79 redds within the southern snorkel transect area and 20 redds were located at Sockeye Beach (Table 16; Figure 5). This count is lower than the 2009 count of 201 suspected redds (Peterson et al. 2011). Areas of excavation (possible redds) are typically large (~3 m x 3 m) and may represent multiple spawning events by multiple

parents; therefore, we do not know how many parents contributed to potential natural production in 2010. Radio-tagged fish moved to areas where redds were observed, and carcasses were recovered to verify spawning.

Radio telemetry data also assisted with collecting information on additional spawning locations during 2010. A total of four areas of excavation were located in Little Redfish Lake, seven sockeye redds observed between Redfish Lake and the confluence of Redfish Lake creek and the Salmon River, three sockeye redds in the Salmon River between the mouth of Redfish Lake Creek and the Sawtooth Fish Hatchery and 29 sockeye salmon redds were counted on Fishhook Creek in 2010.

### **Natural Origin Juvenile Out-migrant Monitoring**

In 2010, 14,012 natural origin smolts (95% CI 12,678 to 15,346) were estimated to have out-migrated from Redfish Lake (Table 13), 45 natural origin smolts (95% CI; not calculated) were estimated to have out-migrated from Alturas Lake, and 3,476 (95% CI 2,936 to 4,016) natural origin smolts were estimated to have out-migrated from Pettit Lake (Table 13, Figure 6). While the SBSTOC believes it is important to utilize reintroduction strategies that produce natural origin smolts (e.g., prespawn adult releases and eyed-egg introductions), it is important to note the difficulty in evaluating the effectiveness of these release strategies in the presence of kokanee and potentially increasing residual populations within the basin lakes. To address these issues, beginning in 2005, we started working with the Idaho Department of Fish and Game's Eagle Fish Genetics Laboratory to utilize DNA microsatellite methodologies to identify individual parental contribution to natural origin smolt production through parental analysis. Parental analysis allows assignment of an individual smolt to parents of a release strategy, allowing comparisons between the relative individual contribution of adults released to spawn volitionally and survival comparisons to certain life history stages (e.g., green egg-to-smolt and/or fry-to-smolt survival) for various release strategies. Results would allow program managers to emphasize the release strategy with the highest reproduction potential. Additionally, parental analysis will allow for evaluation of the reproductive contribution of residuals and estimation of the number of kokanee that emigrate from basin lakes. We have tested the assignments of juveniles from known adult crosses to see how well they assign and have determined that we are able to employ these techniques to samples collected in the field (C. Kozfkay, IDFG, personal communication). We have started analyzing out-migrants from 2010 and will analyze 2011 natural origin out-migrants to answer genetic evaluation questions relating to the various release strategies and the contribution of residual production to this population.

Table 13. Summary of 2010 sockeye salmon smolt out-migration information (by release strategy) at trap locations and at Lower Granite Dam (LGR). Sawtooth Fish Hatchery (SFH) was the rearing location for the fall direct released (FDR) presmolts and smolt release group. Oxbow Fish Hatchery (OFH) was the rearing location for other smolt releases.

Release strategy (rearing location)	Total released <sup>a</sup>	Number tagged prior to release	PIT tags detected at trap	Smolt out- migration estimate	Number tagged at trap	Estimated SURPH survival at LGR	SURPH <sup>c</sup> 95% CI (±)	Estimated no. at LGR
<u>Redfish Lake</u>								
Natural origin smolt	NA	NA	NA	14,012	727	34.00%	9.52%	4,764
FDR presmolt (SFH)	34,561	1,016	72	5,972	614	31.00%	8.23%	1,851
<u>Alturas Lake<sup>b</sup></u>								
Natural origin smolt	NA	NA	NA	45	8	NA	NA	NA
FDR presmolt (SFH)	9,994	1,019	12	899	126	44.00%	20.05%	396
<u>Pettit Lake<sup>b</sup></u>								
Natural origin smolt	NA	NA	NA	3,476	257	25.00%	15.54%	869
FDR presmolt (SFH)	14,983	1,018	184	3,634	106	35.00%	24.72%	1,272
<u>Salmon River</u>								
Hatchery origin smolt (OFH)	45,267	5,983	NA	45,267	NA	25.00%	7.73%	11,317
Hatchery origin smolt (SFH)	73,513	25,810	NA	73,513	NA	16.00%	1.88%	11,762
<u>Redfish Lake Creek</u>								
Hatchery origin smolt (OFH)	34,619	5,962	NA	34,619	NA	17.00%	4.50%	5,885
Hatchery origin smolt (SFH)	25,879	25,851	NA	25,879	NA	15.00%	1.08%	3,882

<sup>a</sup> Total released from hatchery; presmolts = 2009, smolts = 2010.

<sup>b</sup> Data from Alturas and Pettit lake trap obtained from Shoshone-Bannock Tribes biologists.

<sup>c</sup> 95% CIs are two standard errors.

Table 14. Out-migration estimate for natural and hatchery origin sockeye salmon smolts captured at the Redfish Lake Creek trap from April 10 to June 16, 2010.

<b>Natural Origin smolts (one interval estimate)</b>		
	Interval 1	Total
Dates	4/10-6/16/10	4/10-6/16/10
Trap efficiency	0.32	0.32
Marked	727	727
Recaptured	230	230
Total handled	4,446	4,446
Estimated total	14,012	14,012
95% CI upper bound	15,621	15,621
95% CI lower bound	12,615	12,615

<b>Hatchery origin smolts (one interval estimate)</b>		
	Interval 1	Total
Dates	4/10-6/16/10	4/10-6/16/10
Trap efficiency	0.50	0.50
Marked	614	614
Recaptured	303	303
Total handled	2,976	2,976
Estimated total	5,972	5,972
95% CI upper bound	6,532	6,532
95% CI lower bound	5,499	5,499

Table 15. Estimated overwinter survival until out-migration for Sawtooth Fish Hatchery-reared presmolts released in the fall to Redfish, Alturas, and Pettit lakes.

<b>Out-migration Year</b>	<b>Redfish Lake</b>	<b>Alturas Lake</b>	<b>Pettit Lake</b>
2000	29%	34%	46%
2001	20%	75%	29%
2002	40%	30%	29%
2003	15%	NA	59%
2004	27%	54%	35%
2005	35%	82%	56%
2006	43%	38%	64%
2007	23%	26%	25%
2008	27%	53%	59%
2009	25%	31%	54%
2010	17%	9%	24%

Table 16. Redfish Lake Sockeye Salmon Captive Broodstock Program prespawn adult release history.

Lake	Rearing Origin	Date Released	Number Released	Number Of Suspected Redds
Redfish	Full-term hatchery	1993	20	Unknown
Redfish	Full-term hatchery	1994	65	One behavioral observation
Redfish	Full-term hatchery	1996	120	30 suspected redds
Redfish	Full-term hatchery	1997	80	30 suspected redds
Pettit	Full-term hatchery	1997	20	1 suspected redd
Alturas	Full-term hatchery	1997	20	Test digs only
Redfish	Full-term hatchery	1999	18	
Redfish	Hatchery-produced anadromous	1999	3	8 suspected redds
Redfish	Full-term hatchery	2000	46	
Redfish	Hatchery-produced anadromous	2000	120	20 to 30 suspected redds
Pettit	Hatchery-produced anadromous	2000	28	none confirmed
Alturas	Full-term hatchery	2000	25	
Alturas	Hatchery-produced anadromous	2000	52	14 to 19 suspected redds
Redfish	Hatchery-produced anadromous	2001	14	12 to 15 suspected redds
Redfish	Full-term hatchery	2001	65	
Redfish	Hatchery-produced anadromous	2002	12	10 to 12 suspected redds
Redfish	Full-term hatchery	2002	178	
Redfish	Full-term hatchery	2003	315	42 suspected redds
Redfish	Full-term hatchery	2004	241	127 suspected redds
Redfish	Full-term hatchery	2005	173	78 suspected redds
Redfish	Full-term hatchery	2006	464	172 suspected redds
Redfish	Full-term hatchery	2007	494	195 suspected redds
Redfish	Full-term hatchery	2008	398	
Redfish	Hatchery-produced anadromous	2008	571	338 suspected redds
Redfish	Full-term hatchery	2009	682	
	Hatchery-produced anadromous	2009	667	201 suspected redds
Redfish	Full-term hatchery	2010	372	
	Hatchery-produced anadromous	2010	1,210	155 suspected redds
		<b>Total</b>	<b>6,473</b>	

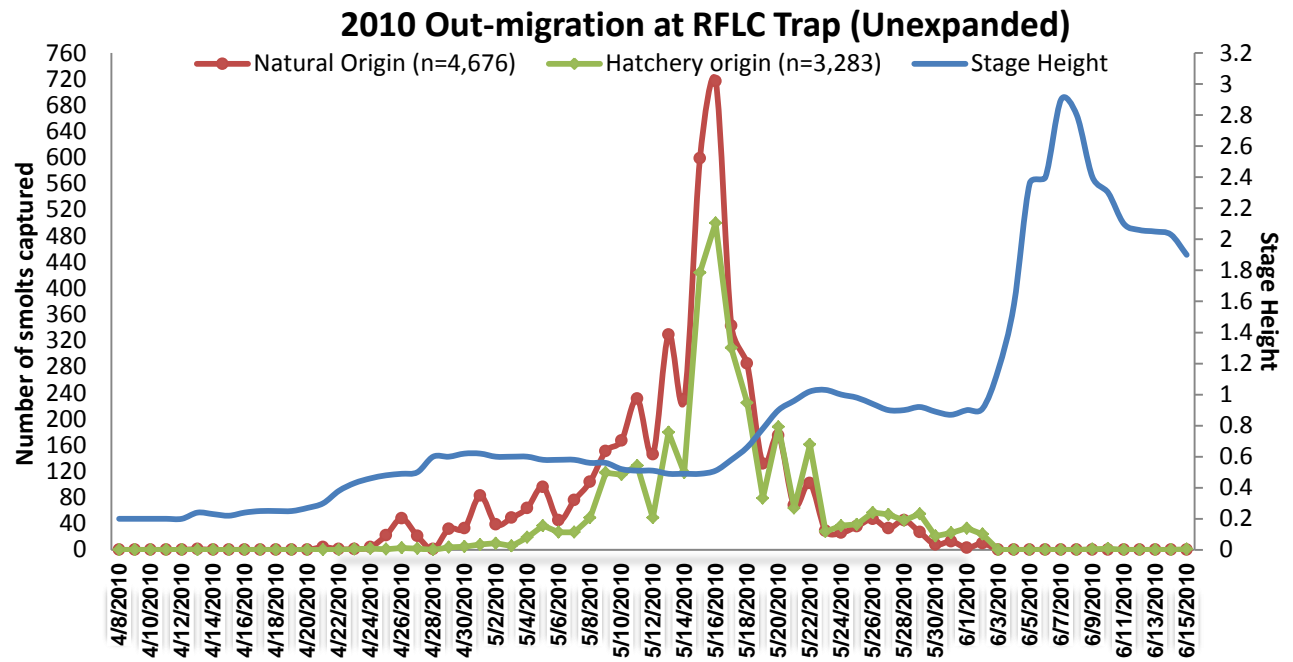


Figure 3. Daily capture of natural origin and hatchery origin sockeye salmon smolts (unexpanded) at the Redfish Lake Creek trap during the 2010 out-migration.

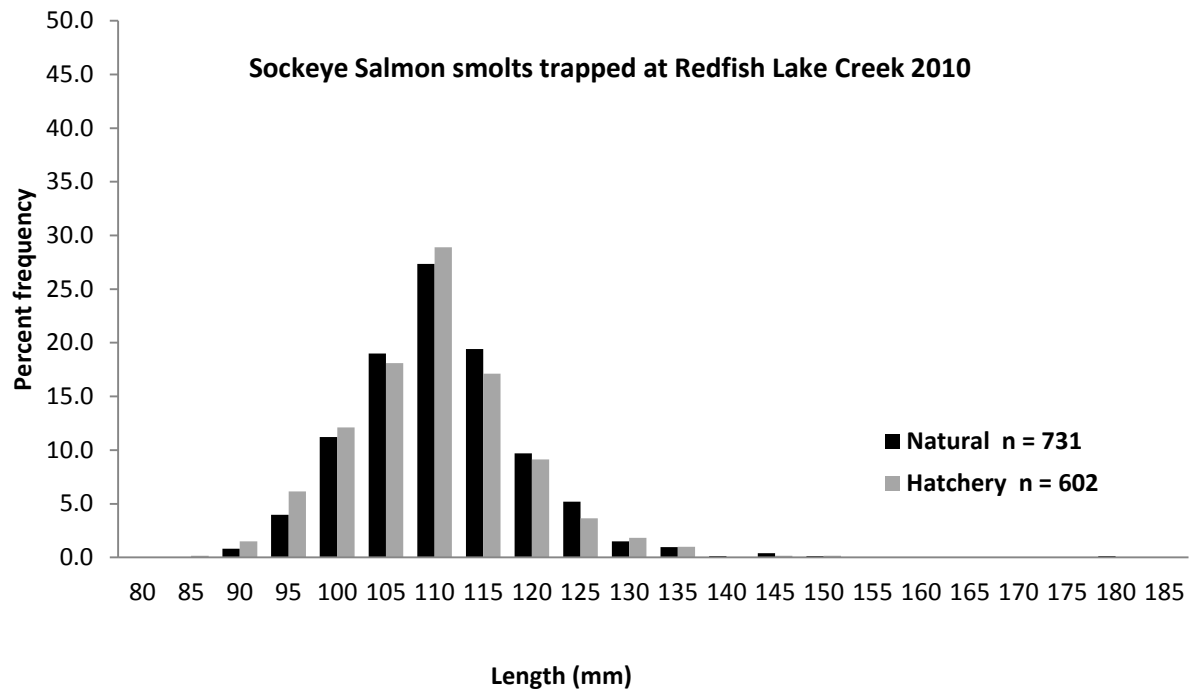


Figure 4. Length frequency of natural (n = 731), and hatchery origin (n = 602) sockeye salmon smolts collected at Redfish Lake Creek trap in 2010.

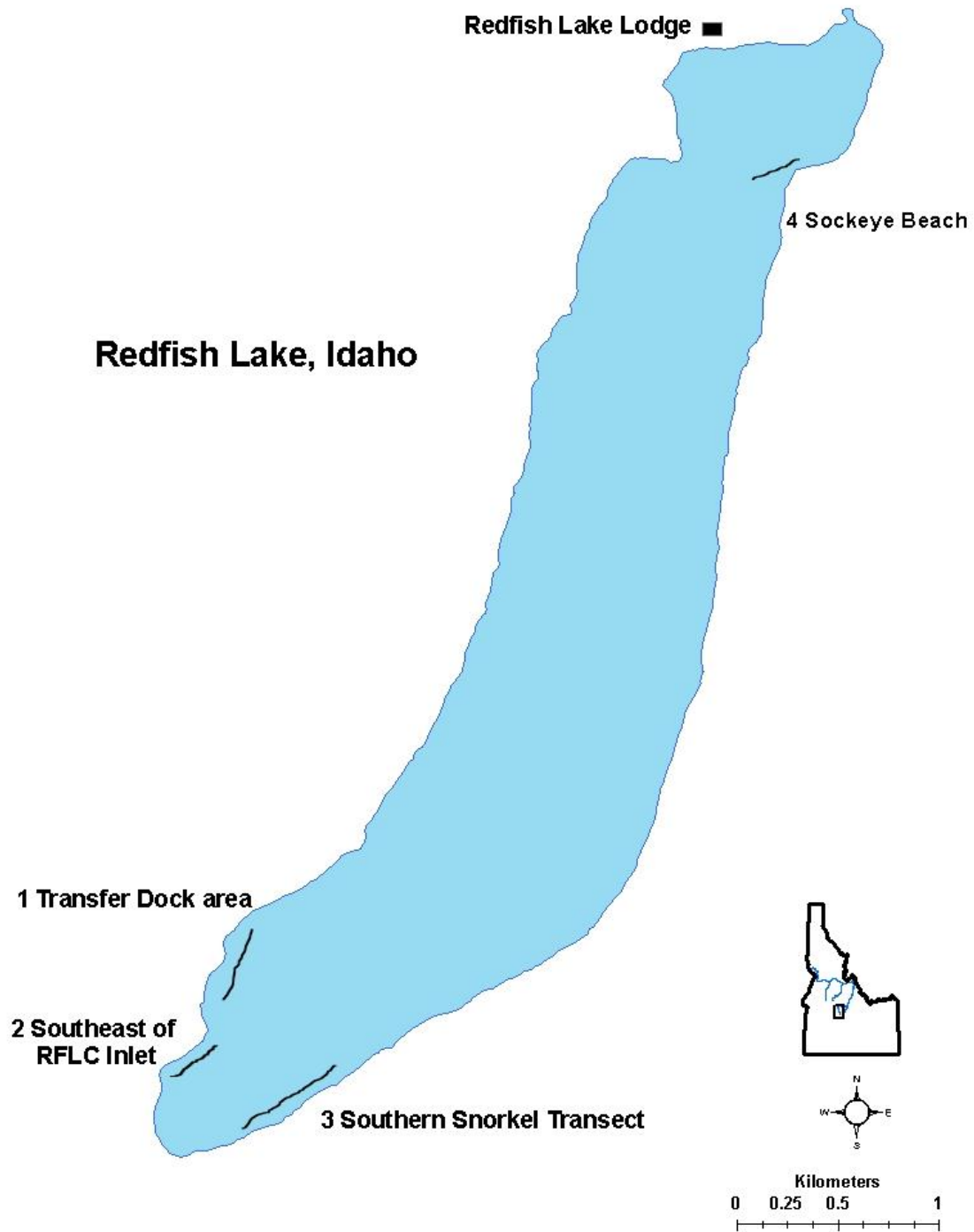


Figure 5. Spawning locations for sockeye salmon in Redfish Lake: 1) area near the U.S. Forest Service transfer camp dock, 2), area southeast of RFLC inlet 3) southern snorkel transect area, and 4) Sockeye Beach used in 2010.

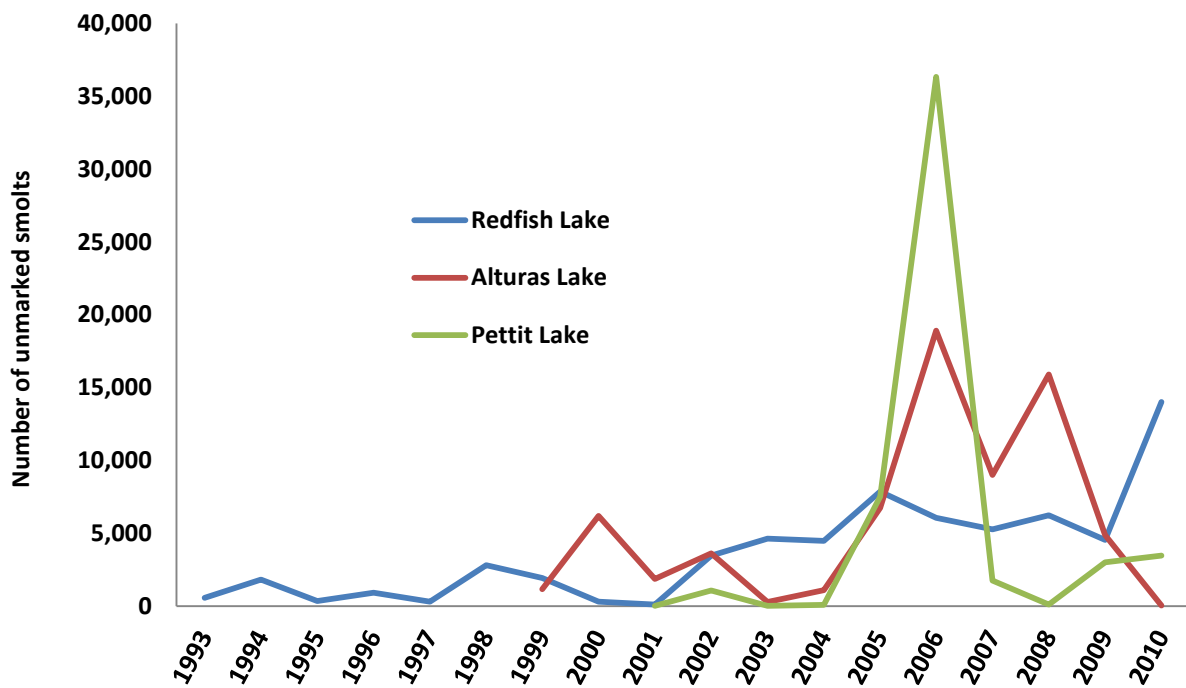


Figure 6. Natural origin sockeye salmon smolt out-migration estimated at Redfish Lake Creek, Alturas Lake Creek, and Pettit Lake Creek traps from 1991 to 2010 (juvenile out-migrant traps on Pettit Lake Creek were not operated every year).

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## **PART 4—PREDATOR SURVEYS**

### **INTRODUCTION**

Declines in bull trout populations throughout the Pacific Northwest led to their listing as threatened under the Endangered Species Act in 1998. Prior to listing, IDFG implemented no-harvest fishing regulations to help protect the remaining populations in the State of Idaho. Because bull trout readily consume kokanee and other salmonids (Bjornn 1961; Beauchamp and Van Tassell 2001), a large increase in the number of adult bull trout in Stanley basin lakes could affect the recovery of sockeye salmon and kokanee populations in the lakes. Bull trout spawner investigations were initiated in 1995 to monitor Redfish and Alturas lakes bull trout populations. Index sections were established on Fishhook and Alpine creeks (tributaries to Redfish Lake and Alturas Lake, respectively) in 1998. Information collected in 2010 represented the 13<sup>th</sup> year data were collected in these index reaches.

### **METHODS**

In 2010, we surveyed the index reaches of Fishhook Creek and Alpine Creek on August 31 and September 13-14, 2010 to enumerate bull trout spawners and redds (Figure 7 and 9, respectively). These dates typically correspond with the initiation of spawning (first survey) and the completion of spawning activities and redd construction (second survey). No suitable tributary streams feed Pettit Lake and, as such, bull trout spawner surveys were not conducted on this system. Index sections were established with global positioning satellite (GPS) equipment. Two observers walked from the lower boundary of the index section upstream and recorded visual observations of bull trout and known or suspected bull trout redds. Coordinates of redd locations were recorded with a handheld GPS unit. In order to avoid omission of completed redds during the final count, completed redds identified during the first count were flagged. Flagging prevents omitting redds from the final count that were obscured over time.

In 2007, an additional area was surveyed for bull trout redds in Fishhook Creek (identified as Fishhook Creek lower site). The new section includes the lower portion of Fishhook Creek upstream of the first gradient gain above Redfish Lake and ends at the wilderness boundary located between GPS waypoints 44° 08.889N 114.55.660W, and 44°08.639N 114°57.384W (Figure 7).

#### **Bull Trout Capture, Mark, and Haul Operations Redfish Lake Creek**

As mentioned previously in this report (Part 3, page 32), during the out-migration season of 2010, trap efficiency at the juvenile out-migrant sockeye salmon trap on Redfish Lake Creek dropped from a five-year season average of 42% to 32%. The marked decrease in trap efficiency was attributed to avian, mammalian, and fish predation observed by trap tenders. Fish predation was attributed primarily to bull trout keying in on the release of marked sockeye salmon used to measure the trap efficiency. In an attempt to develop accurate juvenile sockeye out-migration estimates with reliable trap efficiencies, IDFG attempted to capture bull trout at Redfish Lake Creek trap using angling methods. Each captured bull trout was scanned prior to tagging for juvenile sockeye salmon PIT tags. If smolt tags were identified, they were recorded and the bull trout received a PIT tag (cheek implants) and was transported four miles downstream from the confluence of Redfish Lake Creek and the Salmon River and released.

The adult sockeye weir on Redfish Lake Creek captures all upstream migrating sockeye salmon and bull trout. Trapping in Redfish Lake Creek for adult migrants started on July 16 and continued until October 21, 2010.

## **RESULTS AND DISCUSSION**

### **Fishhook Creek**

In the upper site trend section of Fishhook Creek, we observed 27 adult bull trout and 11 redds on August 31, 2010. During our second survey on September 13, we observed 5 adult bull trout and 6 new redds for a total of 17 completed redds (Table 17). We observed 36 adult bull trout and zero redds on August 31, 2010 in the lower site trend count area on Fishhook Creek. During our second survey on September 13, we observed no adult bull trout and a total of 10 complete redds.

During the 13 years of data collection, we have observed fluctuating population trends in the data. The cyclic appearance in the data suggests normal variation within this population. Copeland and Meyers (2011) identified similar patterns within multiple salmonid populations in Idaho during the same period. Redd counts in Fishhook Creek had been stable or slightly increasing since 1998 (Figure 8). Our findings are consistent with results from statewide monitoring efforts, which indicate that bull trout are increasing or at least stable across most of their range in Idaho (High et al. 2005). Because bull trout may spawn in alternating or consecutive years (Fraley and Shepard 1989), year-to-year variation would be expected.

### **Alpine Creek**

We observed no adult bull trout and no completed redds on both our August 31, 2010 and September 14, 2010 surveys (Table 18). We were unable to identify a blockage to upstream migration before the count in 2010. This was the third year in a row we observed no fish utilizing the original trend area. The Alpine Creek population had increased steadily between 1998 and 2001, followed by a stabilizing period between 2002 and 2007 based on redd count and fish observation data. We have no evidence to believe that the population is collapsing (we observed adults spawning below the original trend area) and suspect that upstream passage is halting the use of the original trend site spawning habitat within Alpine Creek. Therefore, in addition to the original trend area, we plan to establish a second index site below the original area prior to surveys in 2011. By establishing the second trend area below the original trend site, we hope to gain additional information about the population and identify whether we are seeing actual population changes. Documentation of significant population changes have been identified from redd count data (Rieman and Meyers 1997).

We believe that our counts of redds in the trend sections were an accurate reflection of the numbers of redds present. The streams in our surveys were much smaller than those used by Dunham et al. (2001), which indicated that redds could be missed in larger systems. For example, in the systems studied by Dunham et al. (2001), deepwater cover was defined as water greater than 1 m deep. In Fishhook and Alpine creeks, water depth rarely approached 1 m deep.

### **Bull Trout Capture, Mark, and Haul Operations Redfish Lake Creek**

We captured three adult bull trout at the Redfish Lake Creek trap by hook and line that were PIT tagged and transported to the release location on the main Salmon River. No juvenile sockeye salmon smolt PIT tags were detected in the stomachs of the captured bull trout (Table 19).

During the operation of the adult sockeye salmon weir on Redfish Lake Creek in 2010, 652 adult anadromous sockeye salmon and 187 adult bull trout were handled. A portion of the bull trout that were captured and passed received PIT tags ( $n = 136$ ). A total of 11 bull trout mortalities were collected on the upstream side of the weir and are attributed to either angling or post spawn events.

Work done by Schoby (2006) suggests that bull trout in the upper Salmon River migrate from spawning tributaries in early October and that some individuals migrate to Redfish Lake to overwinter. Since 2008, our adult sockeye weir has been operated until mid- to late October, enabling us to collect data on bull trout moving into Redfish Lake to overwinter. The collection of this data should provide us with additional information on how bull trout populations fluctuate in the upper Salmon River drainage and whether predation issues within Redfish Lake are occurring that are not detected by using redd data alone. If increasing numbers of bull trout are migrating into the system to overwinter, we may see predation on *O. nerka* increase within the lake resulting in decreased egg-to-smolt survival as well as lower migration survival during out-migration. With the increase in adult sockeye returns during 2008-2010, we have begun monitoring the egg-to-smolt survival and will continue to monitor the bull trout population to identify changes when possible.

Table 17. Bull trout adult fish counts and redd counts in index sections of Fishhook Creek from 1998 to 2010.

Year	Dates	Number Of Bull Trout Observed	Number Of Redds
1998	8/22	40	5
	9/10	2	11
1999	8/22	40	0
	8/26	33	15
2000	8/31	16	12
	9/14	2	18
2001	8/28	31	15
	9/11	3	11
2002	9/04	23	6
	9/11	5	17
2003	8/27	40	6
	9/08	15	17
2004	8/30	31	7
	9/9	8	11
2005	8/30	24	12
	9/12	2	23
2006	8/29	32	16
	9/13	0	25
2007	8/29	41	21
	9/13	2	22
2008	8/29	29	8
	9/11	5	13
2009	8/27	5	7
	9/11	8	21
2010	8/31	36	11
	9/13	5	17

Table 18. Bull trout adult fish counts and redd counts in index sections of Alpine Creek from 1998 to 2010.

Year	Dates	Number Of Bull Trout Observed	Number Of Redds
1998	8/23	6	0
	9/11	6	1
1999 <sup>a</sup>	8/26	13	3
2000	8/30	18	6
	9/15	5	9
2001	8/28	8	11
	9/11	1	15
2002	8/30	20	8
	9/12	0	14
2003	8/27	27	11
	9/08	0	14
2004	8/31	16	6
	9/9	0	9
2005	8/30	16	9
	9/12	0	13
2006	8/28	15	6
	9/12	1	13
2007	8/28	15	17
	9/12	3	18
2008	8/28	0	0
	9/11	0	0
2009	8/27	0	0
	9/9	0	0
2010	8/31	0	0
	9/14	0	0

<sup>a</sup> Only one count completed.

Table 19. Bull trout relocation effort juvenile out-migrant trapping at Redfish Lake Creek, 2010.

Year	Bull Trout Captured, PIT Tagged, Relocated	Bull Trout Recaptured At Trap Site	Bull Trout With <i>O. Nerka</i> PIT Tags Detected In Stomach	Bull Trout Mortalities Associated With Transport Activities
2009	11	1	0	0
2010	3	0	0	0

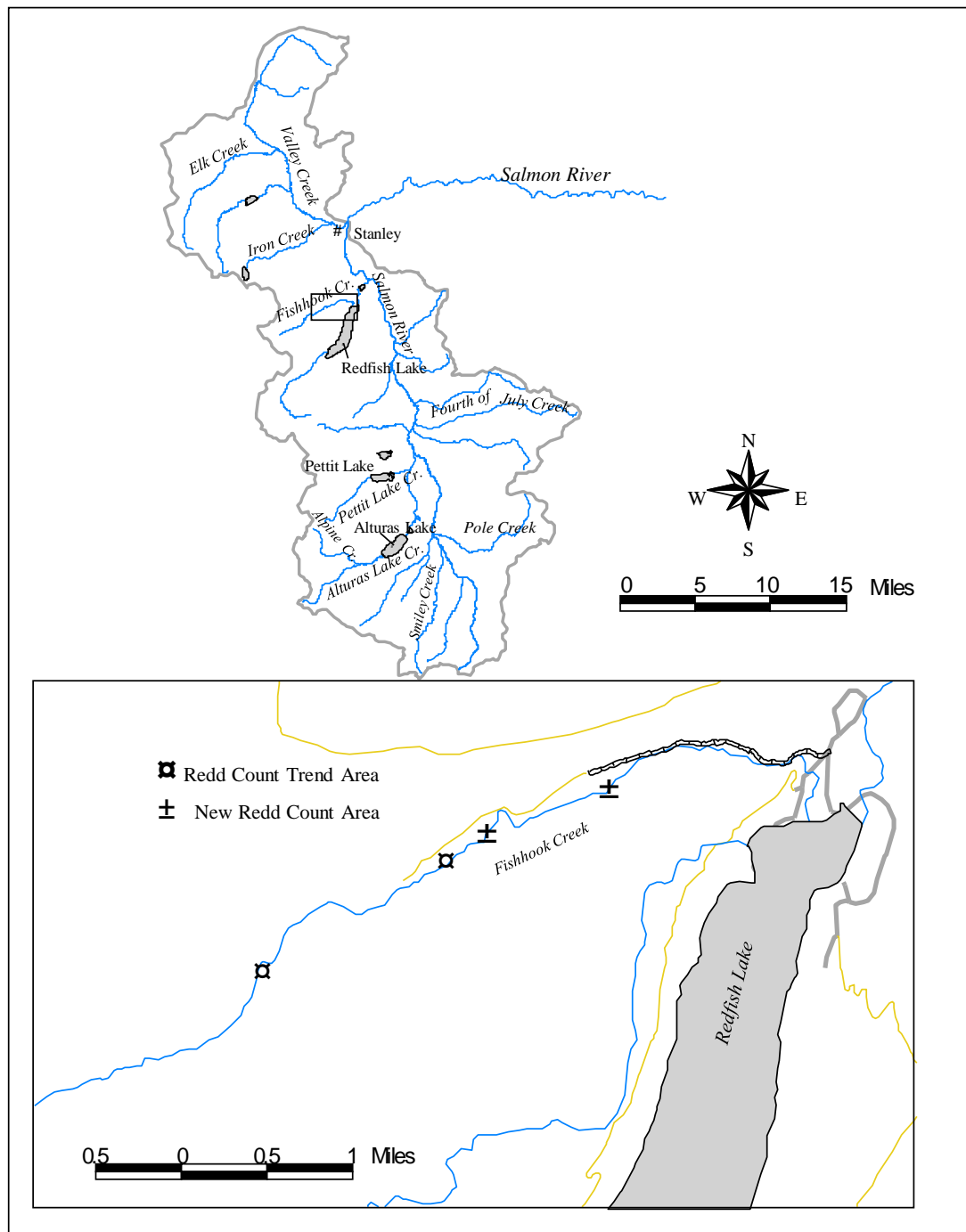


Figure 7. Location of bull trout redd index sections in Fishhook Creek in 2010.

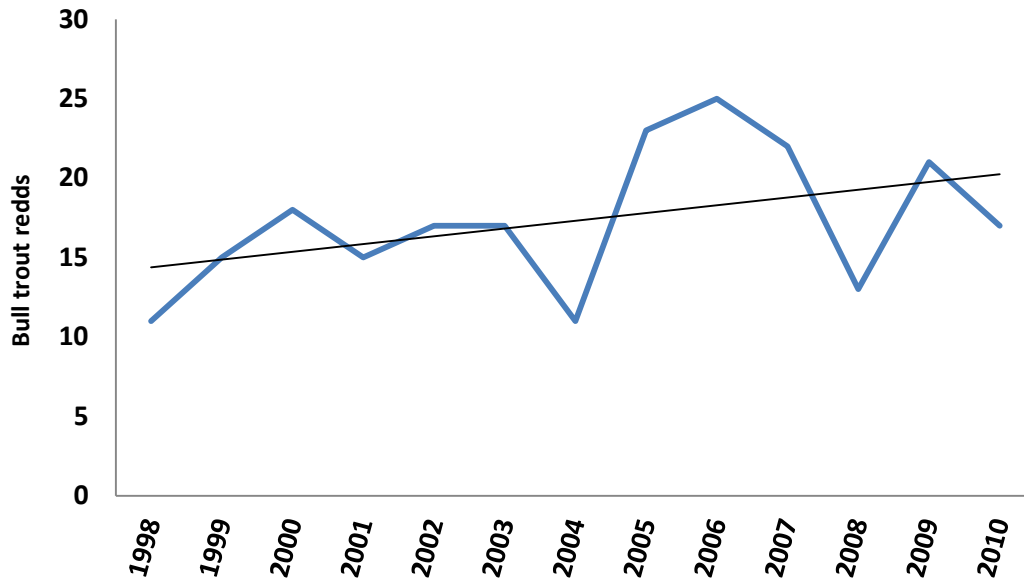


Figure 8. Estimated bull trout redd counts from 1998-2010 within Fishhook Creek. The trend line is used to show the slight increase of bull trout redd production found within Fishhook Creek. The equation for the trend line is  $y = 0.489x + 13.885$  with an  $R^2$  of 0.1838.

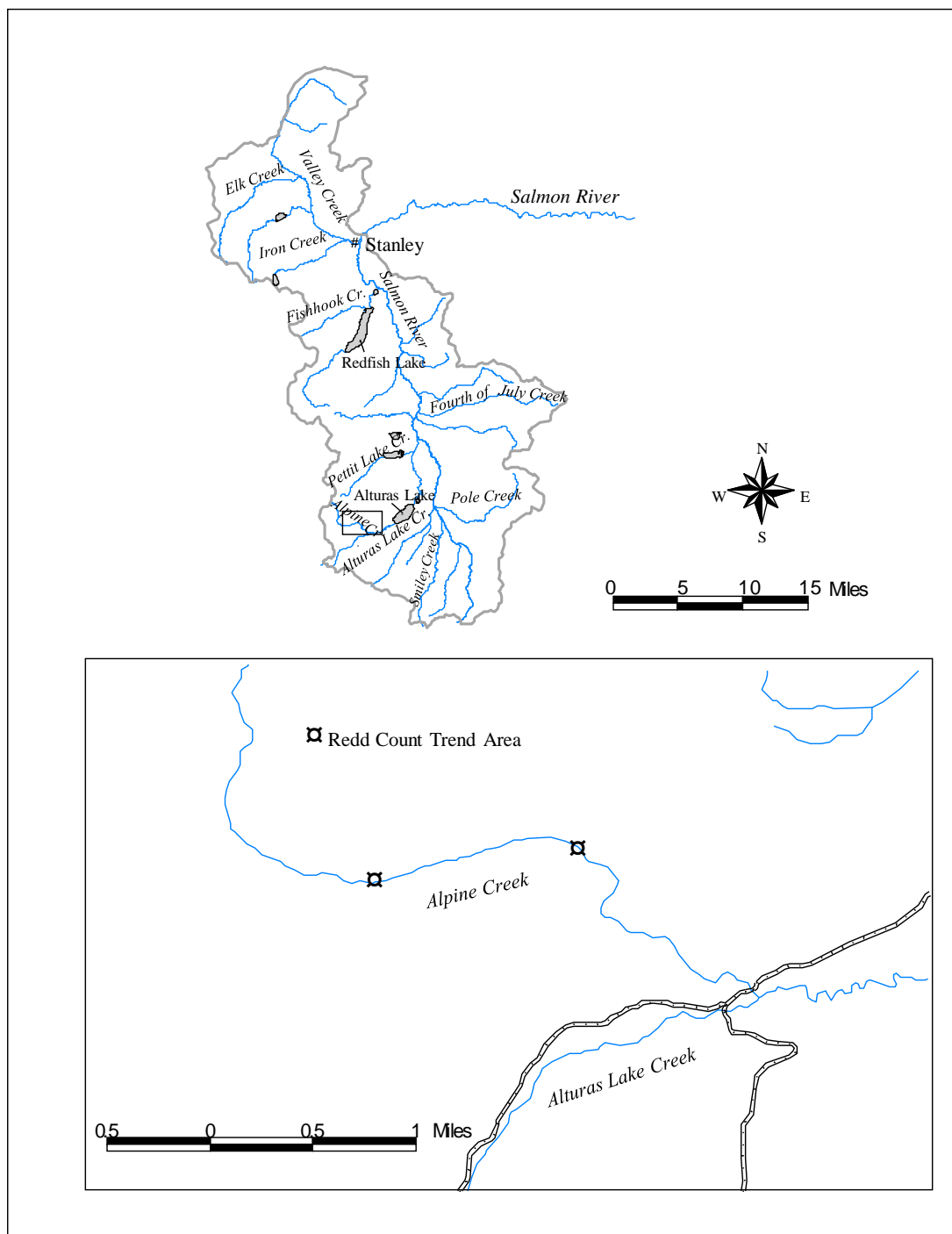


Figure 9. Location of bull trout redd index sections in Alpine Creek in 2010.

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## **APPENDICES**

Appendix A. Fork length, weight (g), and age of *O. nerka* captured during midwater trawls conducted during September 2010 on Redfish, Pettit, and Alturas lakes.

<b>Transect</b>	<b>Length (mm)</b>	<b>Weight (g)</b>	<b>Age</b>
<u>Redfish Lake</u>			
1	64	2.7	
2	45	0.9	0
2	48	1.2	0
2	53	1.4	0
2	56	1.8	0
2	63	2.4	0
2	65	2.9	0
2	62	2.3	0
2	65	2.8	0
2	74	4.1	0
2	93	8.4	1
4	38	0.5	0
4	58	1.8	0
5	42	0.9	0
5	53	1.4	0
5	55	1.8	0
5	72	3.8	0
6	48	1.1	0
6	53	1.4	0
6	67	2.9	0
<u>Alturas Lake</u>			
1	91	6.6	1
1	98	8.5	1
1	96	8.0	1
1	101	10.1	1
1	102	8.9	1
1	98	8.7	1
1	103	10.4	1
1	116	14.7	1
1	140	26.6	2
1	179	47.8	2
2	65	2.3	0
2	78	3.8	0
2	64	2.4	0
2	55	1.6	0
2	76	3.9	1
2	79	4.0	1
2	78	4.1	No Scales
2	80	4.2	1
2	77	3.5	No Scales
2	76	3.5	No Scales
2	64	1.9	0
2	65	2.2	0
2	76	3.8	No Scales
2	71	3.0	0
2	69	2.8	0
2	127	19.2	1
2	112	13.9	1
2	148	31.2	2
2	53	1.3	0

## Appendix A. Continued.

<b>Transect</b>	<b>Length (mm)</b>	<b>Weight (g)</b>	<b>Age</b>
3	74	3.6	No Scales
3	78	4.0	No Scales
3	100	9.9	1
3	97	8.4	1
3	99	8.5	1
3	98	8.8	No Scales
3	100	9.3	No Scales
3	47	0.9	0
3	115	16.0	1
3	107	11.9	1
3	107	9.5	1
3	103	10.8	1
3	95	8.6	1
3	101	8.3	No Scales
3	122	17.5	2
3	138	23.6	2
3	136	23.1	2
3	111	12.8	1
3	114	14.3	2
3	56	1.3	0
3	169	44.9	2
3	190	57.0	3
3	180	50.7	3
4	80	4.6	1
4	77	2.8	No Scales
4	96	9.0	No Scales
4	78	4.2	No Scales
4	79	4.4	No Scales
4	90	5.7	No Scales
4	77	3.9	No Scales
4	76	3.7	No Scales
4	89	5.5	1
4	100	9.2	No Scales
4	120	17.3	1
4	95	8.2	No Scales
4	155	36.7	2
4	116	15.4	1
4	137	25.7	2
4	148	28.3	2
4	163	40.9	2
4	156	37.4	2
5	59	1.6	0
5	78	4.0	No Scales
5	77	4.2	No Scales
5	85	5.6	1
5	103	10.6	No Scales
5	98	8.9	No Scales
5	130	21.4	2
5	169	41.2	2
6	58	1.6	1
6	79	3.8	No Scales
6	118	15.6	1

Appendix A. Continued.

<b>Transect</b>	<b>Length (mm)</b>	<b>Weight (g)</b>	<b>Age</b>
6	121	15.0	1
6	128	19.3	1
6	139	25.6	1
6	176	48.7	2
<u>Pettit Lake</u>			
1	75	4.3	0
1	84	6.5	0
1	187	79.3	2
2	60	2.2	0
2	61	2.5	0
3	68	3.1	0
4	47	1.1	0
4	50	1.2	0
4	54	1.9	0
4	72	3.6	0
4	193	79.5	2
5	65	2.5	0
5	63	2.4	0
5	70	3.7	0
5	192	75.0	2
6	165	55.0	2
6	190	81.7	2

Appendix B. Arrival dates at Lower Granite Dam for PIT-tagged sockeye salmon smolts during the 2010 migration year.

Date	Redfish Lake					Pettit Lake			Alturas Lake		
	Natural Origin	Fall Direct	Hatchery Smolts	Oxbow Smolts	Sawtooth Smolts	Natural Origin	Fall Direct	Hatchery Smolts	Natural Origin	Fall Direct	Hatchery Smolts
5/7/2009											
5/8/2009			1								
5/9/2009											
5/10/2009											
5/11/2009	1										
5/12/2009	1										
5/13/2009					2						
5/14/2009	1				22						
5/15/2009		1			439						
5/16/2009			1	4	506						
5/17/2009			1	9	573						
5/18/2009			1	135	679						
5/19/2009	1	1	3	308	1,658				1		
5/20/2009	1		2	126	1,232				4		
5/21/2009	1	2	8	32	794				1		1
5/22/2009	6		1	4	221		1		3	1	1
5/23/2009											
5/24/2009											
5/25/2009	2	1	2		5	2	10	1			3
5/26/2009	3	5	7		8	5	33	5	1	14	7
5/27/2009	1	3	4		5	2	24	1	2	12	5
5/28/2009	2	3	5	2	2		8	1		5	6
5/29/2009	2		3	1	4		2			1	4
5/30/2009			2		8		1			2	2
5/31/2009	1	1	3		7	1				1	
6/1/2009		1	2		9		2			1	1
6/2/2009		3	4		41		2				
6/3/2009		1	5		54					1	
6/4/2009	1		1		23					1	
6/5/2009			3		32		1				
6/6/2009		1	10		24	1	2			1	
6/7/2009		1	1		3		1				
6/8/2009					7					2	
6/9/2009			1		1		1				
6/10/2009					3						
6/11/2009		2			1						
6/12/2009		1			1						
6/13/2009			1		3					1	
6/14/2009					1						
6/15/2009			2				1				
6/16/2009			1		1						
6/17/2009			1		1						
6/18/2009					1						
6/19/2009							1				
6/20/2009			1								
6/21/2009			2								
6/22/2009											
6/23/2009											
6/24/2009			1								
6/25/2009							1				
6/26/2009											
6/27/2009											
6/28/2009					1						
6/29/2009											
6/30/2009					1						
7/1/2009											
Total	24	27	80	621	6,373	11	91	8	12	43	30

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